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REPORT

OF THE

SUPERINTENDENT

OF THE

UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1901.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

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REPORT

OF THE

SUPERINTENDENT OF THE NAVAL OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., August 26, 1901.

SIR: I have the honor to submit the annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1901.

THE 26-INCH EQUATORIAL.

This instrument has been in charge of Prof. T. J. J. See during the whole year. Owing to the death of Mr. George Anderson, who had been assistant on this instrument for twenty-six years, which occurred in November last, and to the absence after February 1 of the party sent out by the Observatory to observe the eclipse of the Sun in Sumatra, Professor See worked entirely alone for a part of the year. The manual labor alone in using this instrument is considerable, and I consider the showing made in Professor See's report as creditable. This instrument has been devoted to the same general line of work as in previous years, and has been maintained in good order. Professor See's report is herewith transmitted.

THE 9-INCH TRANSIT CIRCLE.

This instrument has been steadily employed on the regular sun, moon, and planet work, a revision of the Astronomische Gesellschaft Zones, and the Zone of Zodiacal Stars undertaken for the Paris Astronomical Conference of 1896. From long service this instrument is in need of important repairs. The pivots have become so worn as to need regrinding, and the illumination should be changed so that the reticule will be illuminated by a beam of light in the optical axis of the instrument, instead of a beam cast from one side, as at present. As soon as the alterations of the 6-inch transit circle, which are noted later, are completed, the whole staff for meridian observations will be transferred to that instrument, and the 9-inch transit circle will be put under repairs. The report of Assistant Astronomer King, in charge of the instrument at the close of the fiscal year, is transmitted herewith.

THE 6-INCH TRANSIT CIRCLE.

Since this instrument was mounted two years ago a serious defect in the form of a diurnal change in the constant of azimuth, following

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changes of temperature, has been a source of annoyance and embarrassment and a serious detriment to the usefulness of the instrument. Since March last a systematic and patient investigation of this defect has been carried on by Professor Updegraff with the object of determining, and if possible removing, the cause. Successive changes have been made in the instrument and its supports as a result of this investigation, without in any way altering its form (which could not be done without entirely rebuilding it), and there is reason to believe that the success of these changes is already assured.

This instrument was built by Messrs. Warner & Swasey, of Cleveland, Ohio, from designs by Prof. William Harkness, U. S. N., following closely the pattern of the latest instruments by Repsold, of Hamburg. It would be presumptuous to criticise the result of the experience of the oldest and most skillful instrument makers in the world, and yet I can not believe that this form of instrument will ever be entirely free from uncertainty in the errors of azimuth or level, or both, for the reason that in order to assure precision in other respects a principle has been sacrificed which has been recognized as fundamental in the construction of astronomical instruments for at least two hundred years, viz, that the instrument itself should be directly supported on a substantial foundation of masonry. In this form of instrument the pivots are supported by a skeleton work of metal by which they are raised sixteen inches above the piers. Differences in the rate of expansion between the masonry of the piers and the metal supports of the pivots become immediately apparent in the azimuth or level of the instrument, and some evidence of this will, I believe, be always apparent. If these errors can be reduced to something manageable under normal conditions, there will still remain the probability that abnormal conditions and sudden and excessive changes of temperature may still make them inconveniently apparent. In this connection I may observe that preparations have been made for a south meridian mark for both the 6-inch and 9-inch meridian circles, but no steps have been taken during the year to erect them.

THE CLOCK SYSTEM.

The effort to bring the department of meridian observations, which is the real *raison d'être* of the Observatory itself, to a state of the highest efficiency and up to the most modern standard of requirement, has included not only a thorough overhauling of both meridian instruments, but also an examination, and if possible an improvement, in the clock system of the Observatory. Critics who are in no way responsible for results, and who probably would not carry out their own suggestions if they were, have had a standing grievance against the Observatory because it has not put its clocks underground. In point of fact very few observatories do put their clocks underground. The notable exception is Pulkowa. It is difficult to maintain a clock underground and not ruin it by rust. The experiment was tried in the very early days of the Naval Observatory and abandoned after the valuable Kessels clock had been nearly sacrificed to the experiment. If, however, a clock can be inclosed in air-tight case from which the air has been partially exhausted, it should be entirely removed from the influences of temperature, pressure, and humidity, and it should, theoretically, be as safe in a vault as above ground. This is the prin-

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ciple which has governed the construction of the clock vault of the Naval Observatory. The vault is dug in the basement of the clock house, which stands on the highest eminence in the Observatory grounds, a knoll of quite abrupt grades, of a gravel soil, and so situated that the natural drainage is away from the vault in all directions. The vault is built with double walls and roof and thick concrete floor, the space between the walls being filled with nonconducting material. The air of the vault is dried by gas and proper provision is made for ventilation. The air-tight cases containing the clocks are of metal and glass, and in each is exposed in full view a rust gauge of bright steel, which is closely watched, and its condition reported to the Superintendent at frequent intervals. The Kessels clock, which is regarded as the standard, is regulated to mean time, and as it is not capable of sustaining the electrical connections necessary for chronometric connection on the clock circuit, it is compared with the sidereal sounder by coincidence of beats by the aid of a microphone, the beats of the clock being wholly inaudible to the unaided ear. So far the whole arrangement has proved on the whole satisfactory, and the rate of the Kessels clock reduced to a constant of almost zero. Some trouble has been experienced in making the clock case actually air-tight, and if the experiment (for I regard it as no more than an experiment) fails, it will be from this cause. Professor Updegraff's report is herewith transmitted.

THE 12-INCH EQUATORIAL.

This instrument has undergone extensive alterations during the year. It was remounted in April, and has been employed, in charge of Assistant Astronomer Theo I. King, since that time. This instrument is used for the benefit of visitors admitted to the Observatory at night.

THE PRIME VERTICAL TRANSIT INSTRUMENT AND THE 5-INCH ALT-AZIMUTH.

These instruments have remained in charge of Assistant Astronomer G. A. Hill, in continuation of the observations for variation of latitude.

I invite the attention of the Bureau to Mr. Hill's report, as evidence of the spirit in which the Observatory has been (and still is) criticised by outside astronomers. Malice has dictated these criticisms, to my knowledge, for thirty years. In this instance ignorance becomes a valuable accessory.

THE 40-FOOT PHOTOHELIOGRAPH.

Photographs have been taken of the sun daily whenever the weather and other circumstances would permit. During the absence of the photographer, Mr. George H. Peters, on duty with the eclipse expedition, his place was supplied by Mr. E. A. Boeger, Computer.

THE TOTAL SOLAR ECLIPSE OF MAY 18, 1901.

By virtue of a provision of the urgency deficiency bill of the last session of Congress, the Observatory was enabled to equip and put in the field an expedition to the island of Sumatra to observe the total

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eclipse of the sun of May 18, under charge of Prof. A. N. Skinner, U. S. N. Professor Skinner's very interesting preliminary report of the expedition and its results is forwarded herewith. A detailed report will appear in conjunction with a report of the eclipse of May 28, 1900, in a forthcoming volume.

It may very reasonably be asked whether, in view of the meager results on account of cloudy weather on the day of the eclipse, the expense of sending an expedition to such a distance was a justifiable outlay of public money. The reply would be that a chance of failure on account of the weather was one of the conditions which attached unavoidably to the undertaking. Other expeditions were less fortunate and secured no results at all. But the real answer is that results no matter how meager, fully justify the outlay, because such results are not to be judged by themselves, but are to be regarded as forming a part of the general sum of observations of this and other eclipses. The problems presented will be solved, not by the recorded observations of any one person at any one time, but by the accumulation of such observations in the general account of human knowledge. From this point of view even one photograph, or a single observation of contact, would have fully justified the entire outlay. At Fort de Kock ten excellent negatives were obtained, which were acknowledged by foreign astronomers to be the best made by any party in the field, and at Solok, the Observatory's other station, contacts were observed and some photographs obtained. I am satisfied with the results.

A serious drawback to the expedition has been the withdrawal for so long a period of an important part of the Observatory's astronomical staff.

An acknowledgement is due the War Department for uniform courtesy to the expedition both on board the transports and at Manila, and to the commanding officer of the U. S. S. *General Alava* for much valuable assistance.

COMPUTATIONS AND PUBLICATIONS.

Since my last report the whole computing force of the Observatory has been assembled in one bureau, instead of being distributed to the various instruments as heretofore. This change has resulted in a decided economy of time and labor, and is generally in the interests of system and efficiency. All astronomical observations, by whomsoever made, are turned over to the computing bureau for reduction, it being understood that the author is consulted as to the methods of reduction and exercises a general supervision in cooperation with the officers at the head of the bureau. Professor Eichelberger has been placed in charge of this bureau, and in his absence with the Sumatra eclipse expedition his place was supplied by Assistant Astronomer King, up to the close of the fiscal year.

During the year the first volume of the new series of Washington Observations has been published and distributed. The second volume is ready for the press and will be printed immediately. A third volume is nearly ready, and other volumes will follow as rapidly as the material can be prepared for the printer, and until the accumulation of unpublished work is exhausted. This breaks the long suspension of printing which has been a source of anxiety for several years. Leniency in criticism of the quality of the work thus issued is not

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asked nor expected. Scientific work must stand or fail on its merits. But it would be an encouragement, little to be expected, if the scientific world of this country could appreciate or acknowledge the efforts to bring up to date work long in arrears. Appreciation from abroad is not wanting, and has been gratefully acknowledged.

THE NAUTICAL ALMANAC OFFICE.

Prof. W. S. Harshman was appointed Director of the Nautical Almanac March 28, 1901. Up to that time and since the retirement of Prof. Simon Newcomb the direction had been in the hands of a professor of mathematics who held the post in addition to his regular duties at the Observatory. The Almanac demands the undivided time and attention of a competent director. This need had become imperative. Professor Harshman has had the advantage of long experience in the office in a subordinate capacity. He has systematized and regulated the office and brought the work up to date, the regular issue of the Almanac three years in advance having failed. The office is now in a high state of efficiency, and general harmony and enthusiasm prevail in its staff. The Nautical Almanac Office has been noted, since its foundation in 1849, for thoroughness and precision in its methods and for superior excellence in its personnel. That this quality is still dominant is shown by the high stand taken by several of its staff in the competitive examinations for professorships. The report of the Director of the Nautical Almanac is herewith transmitted.

THE RECEPTION OF THE PUBLIC DURING THE WORKING HOURS OF THE NIGHT.

During the year there were issued to the general public 765 regular admission cards by this office, and about the same number by the Bureau of Equipment. These cards admit visitors, holding them, to the Observatory during working hours on one night each week. It has been necessary to adopt a rigid system in the admission of visitors, and to limit the number admitted at any one time to the capacity of the dome. The result has been that cards are sometimes issued months in advance of the date for which they are good, for the whole number of persons making application is so far above the capacity of the Observatory that if all were immediately gratified the institution would be completely given up to this and nothing else. Besides the regular cards as above specified special arrangements have been frequently made for Senators, members of Congress, persons in official life, and visiting astronomers; about nine classes in astronomy from various schools, composing fifteen or twenty young persons each, with their teachers, have also been specially accommodated. Some time since I recommended that the admission of the public during working hours at night be wholly suspended. The numbers seeking admission seem to be constantly increasing. I believe that the Naval Observatory is the only observatory in the world, except a few which have been founded and are conducted avowedly for popular purposes, at which this practice exists. In every department of the Government the public is excluded from certain sections and offices in which its presence would be detrimental to the public interests. The Naval Observatory stands as an exception to this rule. But it is only of late years that this practice

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has prevailed at the Observatory. I am familiar with the conditions which led to the abrogation of a rule which had been rigid from the foundation of the Observatory, and I can say that the purpose then in view was not in the slightest degree subserved by this concession to public curiosity.

The work of the Observatory is so purely technical in character that it can be said, without in the least impugning either the motives or the intelligence of the visiting public, that to no one not versed in practical astronomy would any detailed explanation of the methods of that work be either interesting or intelligible. Consequently, popular subjects must be sought for the gratification of visitors. These are the objections to the practice of admitting visitors during working hours. On the other hand, I can not say that the presence of visitors on one evening a week is a serious interference with the work of the Observatory. Visitors are never admitted to the transit rooms. The 12-inch equatorial is withdrawn from its regular assignment for a few hours in the early evening once a week. If there were but one equatorial telescope at the Observatory this might be a serious interference. As it is, provision for visitors can be made without serious interruption of necessary or emergency work.

I am of the opinion that the concession never should have been made in the first instance. But the practice once established, under proper restrictions, it becomes a delicate and invidious matter to recommend its total suspension, the more so as almost without exception in the experience of the Observatory the appreciation of the privilege on the part of those who have enjoyed it is very marked.

THE BOARD OF VISITORS.

The Board of Visitors established by the naval appropriation act approved March 3, 1901, which went into effect on July 1, met in April, and since that time and prior to July 1, two duly constituted committees of the board have visited the Observatory officially. The law provides for one "annual visitation to the Observatory at a date to be determined by the Secretary of the Navy, and * * * such other visitations, not exceeding two in number annually, by the full board or by a duly appointed committee as may be deemed needful or expedient by the majority of the board." The board has already made the full number of visits allowed by law to any one year.

THE DEPARTMENTS OF NAUTICAL INSTRUMENTS, OF GENERAL STOREKEEPER, AND OF CHRONOMETERS AND TIME SERVICE.

By the detachment of Lieut. Commander Charles E. Fox in May, the last remaining officer of these departments was withdrawn, and all of these important departments left without any regularly assigned personnel whatever. The regulations for the government of the Observatory issued by the Department provide for three officers for this work. I believe this situation is unique in the public service. It is hard to make bricks without straw, but that is the situation of these departments at the present time.

As the work could not cease, a computer, previously detailed from the astronomical department, has been put in charge of these departments, with one of the clerks of the Observatory in charge of the

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books. This arrangement is not only improper, but is prejudicial to the service and injurious to the individual. I have in previous reports made specific recommendations looking to the establishment and maintenance of a permanent force for these departments. I renew these recommendations. The accompanying reports show the volume of business in these departments for the year.

MAGNETISM AND METEOROLOGY.

As noted in my last report, magnetic observations have been discontinued. Meteorological observations are kept up under the same conditions as have prevailed since the establishment of the Observatory.

GROUNDS AND ROADS.

The naval appropriation act carried a fund for the purchase of lands lying within the Observatory Circle not included in the original purchase. Steps have been taken for the immediate acquisition of these lands. I renew my recommendation that none of the outlying tracts be sold at present. Most of this land is wooded, and affords a screen for the Observatory buildings, and until the extension of Massachusetts avenue is completed it would be impossible, I believe, to dispose of this land to advantage. On general principles it is good policy for the United States to hold on to all the land it owns in the District. The grounds are gradually improving, and the buildings are in good order. A house provided for the foreman and captain of the watch by the appropriation of last year has been completed and is occupied. It is a decided advantage in the care of public property and the interests of the establishment to have this official resident upon the place.

LIBRARY.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1900	17,600	3,817	21,417
Accessions	425	74	499
Contents July 1, 1901	18,025	3,891	21,916

Of the accessions, 293 were received as exchanges and 206 were purchased. The following publications were distributed in regular exchange:

Report of the Superintendent for 1900.
Astronomical, Magnetic, and Meteorological Observations made during the year 1891.
Astronomical, Magnetic, and Meteorological Observations made during the year 1892.
Publications, U. S. Naval Observatory, 2d series, volume 1, Sun, Moon, Planets, and Miscellaneous Stars, 1894–1899.

PERSONNEL.

The following changes have taken place in the personnel of the Observatory during the fiscal year:

Lieut. Commander Charles E. Fox, U. S. N., reported for duty on November 7, 1900, and was assigned to the Departments of Nautical

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Instruments, of General Storekeeper, and of Chronometers and Time Service as the relief of Lieut. Commander B. W. Hodges, U. S. N., who was detached on March 15, 1901.

On May 14, 1901, Lieut. Commander Fox was temporarily detached to attend a course of instruction at the Naval War College, Newport, R. I., and was absent the remainder of the fiscal year.

Prof. S. J. Brown, U. S. N., was detached on March 25, 1901, from the Naval Observatory and as Director of the Nautical Almanac, and Prof. W. S. Harshman, U. S. N., was appointed Director of the Nautical Almanac on March 28, 1901.

In the astronomical department there were eleven miscellaneous computers temporarily appointed during the year. Three of them have received permanent appointments, Miss Clara M. Upton, Miss Eleanor A. Lamson, and Mr. Everett I. Yowell, and two are still serving probationary periods.

Mr. W. W. Dinwiddie was appointed a laborer on September 10, 1900, and promoted on November 9 to skilled laborer to succeed George Anderson, who died on October 21, 1900.

On January 30, 1901, another laborer, Gustave Harrison, was appointed to the vacancy caused by the promotion of Mr. Dinwiddie.

I am, sir, your obedient servant,

C. H. DAVIS,

Captain, U. S. N., Superintendent of the Naval Observatory.

The CHIEF OF THE BUREAU OF EQUIPMENT, NAVY DEPARTMENT.

THE 26-INCH EQUATORIAL.

SIR: I have the honor to submit the following report on the work of the 26-inch equatorial:

During the year which has just closed this instrument has been devoted to the same general lines of work as in former years. The machinery of the instrument has been improved by thorough ordering, and by slight readjustment of parts of the driving clock, and in consequence its general performance is more satisfactory than at any time since the removal to the new Observatory. The illumination of the dome and of the micrometer and circles of the instrument has been rearranged, and is now highly satisfactory. The observer may illuminate any part of the instrument, or its accessories, by turning electric switches conveniently placed on the instrument or on the walls. And when total darkness of the dome is required, in the observation of the faintest objects, a covered lamp on the table enables the assistant to see the page of the note book without inconvenience to the observer.

Ever since its installation, the elevating floor, operated by hydraulic rams, had occasioned more or less trouble, from the inability of the control valve to hold it at any elevation to which the observer might set; the resulting instability of the floor, which usually acquired a slow creeping motion, proved a source of much anxiety and embarrassment, especially when the observer worked alone. Accordingly, in September, 1900, a new control valve, of the form used on the elevators in the building of the Navy Department, was substituted; and the

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elevating floor has since performed with entire satisfaction. This improvement in the operation of the floor was especially important in the observations of Eros.

I. PARALLAX OBSERVATIONS OF EROS.

The observations of Eros for the parallax of the Sun were made in accordance with the plans formulated by the International Committee at Paris, and extended over the period from October 9, 1900, to January 29, 1901.

During this period the planet Eros was observed on every available clear, or partially clear, night; and whenever possible, at both ends of the night. The aim was to furnish material for the deduction of the solar parallax by combining the Washington observations with those supplied by other observatories in both hemispheres, or by employing the principle of the diurnal motion of the Earth during the night, and thus deriving the solar parallax from the Washington observations alone. This latter method would have some advantages, in that the observations would all depend on the same observer with the same instrument; while the former would depend on many observers using instruments of various sizes and kinds, and thus working with apparatus more or less heterogeneous. To enable both methods to be used in the final reduction of the work, the position of Eros, relative to comparison stars, was measured three or four times in the evening, between the instant of darkness and eight o'clock, for combination with the measures taken simultaneously at the leading European observatories; and then again observed in the morning, when west of the meridian about six hours.

Observations of this kind were secured on 61 evenings and on 31 mornings. The total number of complete observations was 255, representing something over 5,000 observations with the micrometer. The general aim of the observer was to secure the highest possible accuracy from a reasonable number of observations advantageously distributed through the night, and on as many nights as possible. Observations in the morning hours were made with considerable difficulty, on account of the increased cloudiness of the latter half of the night. It is believed, however, that the conditions under which the work was done on the whole were favorable.

The Eros work was reduced and ready for the printer on June 25. The prosecution of these very delicate parallax observations necessitated a thorough investigation of all the constants of the instrument. The full discussion of these constants will appear in the introduction to the Eros work. The following summary of the chief results will probably suffice for the present report:

1. The value of a revolution of the micrometer screw was determined from differences of declination of stars in the Pleiades, and in the arc h Persei, and by transits of circumpolar stars, and found to be $R=9''.9286\pm0.''0005$. The temperature coefficient appears to be practically insensible.

2. The error of elevation of the polar axis, determined from observations of the declinations of Nautical Almanac stars near the meridian, $\xi=-67''.8\pm1''.0$.

3. And the flexure of the tube, $e=-1''.6\pm0''.5$.

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4. The error of the polar axis found from the observation of pairs of standard stars of different declinations near the meridian, $\eta = +110''.0 \pm 1''.6$.

5. The collimation found from observations on a collimator mounted on the base of the dome of the equatorial and pointed on the Helmet of Liberty Statue on the Dome of the United States Capitol, $c = +117''.7 \pm 1''.9$.

6. The error of rectangularity in the declination and polar axes, found from observations of standard stars near the meridian, $i_1 = +104''.1 \pm 4''.7$.

7. The arc by which the instrumental pole departs from the celestial pole, $\gamma = 129''.3 \pm 1''.9$; $\vartheta = 121° 39'$.

8. Flexure of the declination axis, $\varepsilon = +1''.6 \pm 1''.0$ (assumed).

9. The constant, $i = i_1 - \varepsilon \sin \varphi = +105''.1 \pm 4''.7$. From observations of circumpolar stars at upper and lower culmination the flexure of the declination axis, ε, appeared to be insensible, and was therefore taken to be equal to the differential flexure of the tube. The values of ξ and η seem to have remained quite constant since the telescope was put in use at the new site in 1894. These errors are somewhat larger than are desirable in the final adjustment of the instrument. A slight readjustment of the polar axis is accordingly in contemplation. The pier is so firm that the orientation of the instrument ought then to be entirely satisfactory.

II. THE DIAMETERS OF THE PLANETS AND SATELLITES.

The observations of the diameters of the planets and satellites noted in the last annual report have been continued.

Venus.—Seventeen determinations of the diameter of this planet were taken in July and August, making, with those secured before June 30, 1900, a total of 32 determinations about the inferior conjunction of July 7, 1900. To obviate as far as possible the effects of irradiation the measurements were made from the points of the cusps. The result of this work, done under what are thought to be extremely favorable conditions and with the color screen, was a diameter of $16''.800 \pm 0''.022$, in very close agreement with the value deduced by Dr. Auwers from an elaborate discussion of the transits of 1874 and 1882. No markings were seen on the surface of the planet, although the definition on several occasions was perfect.

Jupiter.—Diameters of this planet have been taken on 4 nights, and of the satellites on 10 nights. Prior to June 30, 1900, Jupiter had been measured on 19 nights, and the satellites on 8 nights; accordingly, the number of determinations of diameter during the opposition of 1900 was 23 for Jupiter and 18 for the satellites. Measurements were taken of both equatorial and polar diameters, with a view of finding the dimensions of the spheroid, and also of deducing the true ellipticity of figure, which had remained somewhat uncertain on account of a discordance which developed between the values obtained by observation and those computed by the theory of gravitation from the motion of the perijove of the fifth satellite. For the theoretical oblateness Cohn, in 1896, found a value of 1:15.50; subsequently W. S. Adams, using observations up to 1899, made it 1:15.55.

The micrometer measurements of the 26-inch equatorial on 22 nights make the observed oblateness $1:15.53 \pm 0.21$.

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The equatorial diameter of the planet came out $38''.401 \pm 0''.038$.
The resulting diameters of the satellites were:
Satellite I, $0''.672 \pm 0''.098$.
Satellite II, $0''.624 \pm 0''.078$.
Satellite III, $1''.361 \pm 0''.103$.
Satellite IV, $1''.277 \pm 0''.083$.
The diameters of all four of these satellites are still under investigation.

Saturn.—The diameter of this planet was measured on 23 nights. The value of the equatorial diameter deduced from 35 determinations during the opposition of 1900 is $17''.448 \pm 0''.025$.

The ring system was subjected to careful measurement, with the following results:
External diameter of outer ring, $40''.304 \pm 0''.030$.
Internal diameter of outer ring, $34''.787 \pm 0''.022$.
Diameter of the center of Encke's division, $37''.777$.
Width of Encke's division, $0''.107$.
Total width of the outer ring, $2''.758$.
Width of the outer part of the outer ring, $1''.237$.
Width of the inner part of the outer ring, $1''.414$.
Width of Cassini's division, $0''.418 \pm 0''.010$.
External diameter of central ring, $33''.951$.
Internal diameter of central ring, $25''.952 \pm 0''.048$.
Width of central ring, $4''.000$.
Internal diameter of dusky ring, $20''.582$.
Width of dusky ring, $2''.685 \pm 0''.033$.
Black space between Saturn's globe and dusky ring, $1''.567$.
Diameter of the satellite Titan, $0''.487 \pm 0''.020$.
The width of the dusky ring and the diameters of Titan and Japetus have been measured several times during the opposition of 1901.

Mercury.—Three series of measurements have been secured of the diameter of this difficult planet. The first two were preliminary and made while searching for the best conditions, the last being that finally adopted. One hundred determinations in June, 1901, when Mercury was near its greatest eastern elongation, make the diameter $5''.8993 \pm 0''.0080$. This presents a considerable departure from Bessel's value of $6''.68$, which was deduced from measures with the Königsberg heliometer in the transit of 1832, and is more in accord with determinations made at the Lick Observatory by Barnard and Campbell during the transits of 1891 and 1894.

Mars.—The great distance of Mars at the recent opposition and the unfavorable weather then prevailing rendered it inadvisable to attempt anything more than a preliminary determination of the diameter, which was made by daylight in June, 1901. Sixty-nine determinations of the polar diameter on eight days, when the sun was from one to three hours above the horizon and the seeing practically perfect, lead to the value $9''.222 \pm 0''.013$. With an oblateness of 1:200 this would give an equatorial diameter of $9''.268$. Experiments recently made on the irradiation constant for Mars fix its value at $+0''.76$. The application of the resulting correction of $-0''.76$ would have the effect of diminishing the diameter of Mars, as ordinarily observed at night and reduced to unit distance, by about $0''.38$. The diameter of Mars concluded from a careful study of the micrometer measures of many observers working at a distance of about 0.5

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and reduced to distance unity is 9″.68. The concluded equatorial diameter of the solid globe of the planet is therefore 9″.30, in substantial agreement with the value found by Professor Campbell at the Lick Observatory in 1894. This value has been used in a new discussion of the mass of Mercury recently made by the method of Prof. G. W. Hill, based on an extension of Laplace's law for the internal density of the earth. The resulting mass of Mercury is $\frac{1}{6012810}$. Most of the masses heretofore assigned this planet have exceeded $\frac{1}{3000000}$; the smallest yet deduced being one found by Prof. G. W. Hill, $\frac{1}{11634200}$. It is perhaps a little remarkable that an observation of the year 1639 by the English observer Horrocks, when used in certain perturbative equations of Leverrier, leads to a mass of only $\frac{1}{11120000}$, which appeared so small that Von Haertdl rejected it altogether. Future investigations must determine whether this ancient observation does not after all afford a good first approximation of the true mass of Mercury, which has remained more uncertain than that of any other primary planet of the solar system.

III. OBSERVATIONS OF THE SATELLITES.

Satellites of Saturn.—A series of micrometer measurements were made during the opposition of 1900 on the four brighter satellites, Titan, Rhea, Dione, and Tethys. The general plan of the observations is similar to that employed by Prof. Hermann Struve in his well-known work at Poulkowa. Titan and Rhea were observed on 59 nights, Dione and Tethys on 49 nights; 38 of the first group of observations fell within the present fiscal year, and 35 of the second group.

On April 16 observations were resumed for the opposition of 1901, and all the satellites searched for on every available clear night. Before June 30, 1901, the following observations had been secured:

Japetus and Titan were measured on 22 nights.
Hyperion and Titan were measured on 11 nights.
Titan and Rhea were measured on 28 nights.
Dione and Tethys were measured on 26 nights.
Tethys and Enceladus were measured on 19 nights.

The reticule of the micrometer has been provided with a system of parallel webs separated by a distance of 624″.65, which makes it possible to refer Japetus at greater elongation directly to Titan in any part of its orbit, by sliding the eyepiece to bring the two objects successively into the field of view. As the driving clock performs very perfectly, and the mounting of the telescope is extremely rigid, it is hoped that this direct measurement will give data for improving our knowledge of the mass of Saturn, as well as for determining the orbits of the satellites. Hyperion has been recognized without great difficulty except when the sky was strongly illuminated by the moon, or very moist, so that the light of the planet was greatly diffused over the field.

Satellites of Uranus.—During the opposition of 1900 Oberon and Titania, the two outer satellites of Uranus, were observed on 35 nights, 16 of which came within the present fiscal year. During the opposition of 1901 observations of these bodies have been made on 23 nights prior to June 30. The two inner satellites, Ariel and Umbriel, also have been successfully measured by using the color screen to reduce the light of

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the field about the planet, the former on 8 nights, the latter on 9 nights. In view of the fact that these inner satellites, which on the whole are recognized to be the most difficult bodies of the solar system, were found by Professors Newcomb and Hall to be near the limit of the powers of this telescope, when Uranus was much nearer the zenith, this result of the darkening of the background of the sky by the use of the color screen is gratifying. Umbriel is usually somewhat more difficult than Ariel, though in the present position of Uranus both require a very dark field to bring them within the grasp of the observer.

IV. DOUBLE STARS.

On account of the heavy demand upon the observer's energies in other lines, only a limited number of double stars have been measured during the past year. About thirty difficult pairs, drawn mainly from Burnham's lists, have been observed at odd moments when the telescope was not otherwise employed. With the increase of force on the instrument following the assignment of Computer George K. Lawton, June 14, the hope was entertained of utilizing its powers to their full extent. The lamented death of this talented and accomplished young astronomer, July 25, 1901, after a month's service on the instrument, was not only an irreparable loss to the 26-inch equatorial, but in view of his youth, fine training, high promise, and noble character, altogether one of the greatest losses ever sustained by the Observatory at any period of its history. His abilities were of the highest, his performance of duty beyond all praise. As he had only commenced independent observations, after a broad experience in several lines, it will be very difficult to do adequate justice to his memory, either by the publication of the work which he left unfinished or by the conclusion of those researches upon which he had just entered with so much promise and enthusiasm. It should be stated here that the problems arising in connection with the Eros work were treated largely under the supervision of Mr. Lawton, who had immediate charge of these reductions from the first. In connection with the parallax measures of Eros, and as a volunteer labor outside of his official duties, he made a number of observations for improving the orbit of the planet. He also secured a considerable series of observations of comet Brooks, 1900, and was occupied with the computation of a definitive orbit when his labors were interrupted by illness, which soon proved fatal. In the latter part of June he made some observations of Proserpina, which were communicated to Professor Neugebauer, and had entered upon the measurement of double stars.

PERSONNEL.

The personnel of the instrument during the past year has been as follows:

T. J. J. See, Professor of Mathematics, U. S. N., astronomer in charge.

George K. Lawton, Computer, assistant observer, from June 14 to July 25, 1901.

W. W. Dinwiddie, Assistant on the 26-inch equatorial (absent on the eclipse expedition to Sumatra from February 5 to July 26, 1901).

Miss Clara Upton, Miscellaneous Computer, from June 14 to July 1, 1901.

Important volunteer assistance has been rendered by Mr. George H. Peters and Mr. L. G. Hoxton.

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Mr. Gustave Harrison has aided in the observations about half of the time covered by Mr. Dinwiddie's absence on the eclipse expedition to Sumatra.

In conclusion it may be said that the general condition of the building and instrument is satisfactory.

The following papers relative to the work of the 26-inch equatorial have appeared during the year:

1. Preliminary Researches on the Diameters of the Planets Neptune and Uranus. (Astronomische Nachrichten, 3665.)
2. Researches on the Diameter of Venus. (Astronomische Nachrichten, 3675,)
3. Researches on the Figure and Dimensions of Jupiter and on the Dimensions of his Satellites. (Astronomische Nachrichten, 3670.)
4. Observations of Titania and Oberon, the two outer Satellites of Uranus. (Astronomische Nachrichten, 3676.)
5. Researches on the Equatorial Diameter of Saturn and on the Dimensions of his System of Rings. (Astronomische Nachrichten, 3686–87.)
6. Observations of the Four Brighter Satellites of Saturn. (Astronomische Nachrichten, 3714.)

Papers on the Diameter of Mercury, the Mass of Mercury, and the Diameter of Mars have been communicated to the Astronomische Nachrichten.

Respectfully,

T. J. J. See,
Professor of Mathematics, U. S. N.,
In charge 26-inch Equatorial.

The Superintendent, Naval Observatory.

THE 9-INCH TRANSIT CIRCLE.

Sir: I have the honor to submit the following report of the work of the 9-inch transit circle during the year ending June 30, 1901. The instrument was under the charge of Professor A. N. Skinner, U. S. N., until February 5, 1901. While he was absent to observe the eclipse of the sun, Professor W. S. Harshman, U. S. N., directed the work from February 7 to March 28, 1901, and Assistant Astronomer Theo I. King after the latter date. The assistants during the year were Professor W. S. Eichelberger, U. S. N., until February 7, 1901; Professor Harshman, from September 6, 1900, to March 28, 1901; Assistant Astronomer King, Computers W. M. Brown and E. A. Boeger throughout the year; Computer G. K. Lawton until December 8, 1900, also from March 11 to June 7, 1901; Computer J. C. Hammond from August 15, 1900, to March 11, 1901, and Mr. E. I. Yowell after June 7, 1901.

The instrument was used with the clamp west until November 12, 1900; since that date the clamp has been east. While the telescope was being reversed the pivots were accurately measured; the suspicion was confirmed that they had become unevenly worn. A careful investigation by means of the mercury and hanging levels and contact lever, extending from October 28 to November 24, was conducted by Professors Skinner and Eichelberger. This defect, which necessarily affects the reduced positions of objects observed, should be remedied at the earliest possible day. At the same time some of the improvements suggested by the Board of Visitors might be made. It is specially desirable that the counterpoise rollers should be renewed, many of the parts of

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the micrometer replaced, and improvements effected in illuminating the reticule and microscopes.

The regular sun, moon, and planet work was directed by Professor Eichelberger until September 12, 1900; from that date to March 28, 1901, by Professor Harshman, and subsquently by Assistant Astronomer King.

The Astronomische Gesellschaft zones are still incomplete, a number of revision zones having been taken during the year, while two or three more will be needed. These revision zones have been observed by Professor Skinner and Assistant Astronomer King, with the assistance of Assistant Astronomers King and F. B. Littell.

The zone of Zodiacal stars, undertaken for the Paris Astronomical Conference in 1896, was begun in September by Professor Eichelberger, with the help of Computers Lawton and Hammond, but was suspended after the discovery of the unsatisfactory condition of the pivots.

Observations of the planetoid Eros and the primary list of 319 comparison stars desired by the Astrophotographic Conference were made by Assistant Astronomer King, aided by Computers Brown, Boeger, Hammond, and Mr. R. Y. Ferner.

The following summary shows the number of observations of the various objects:

Ephemeris stars	2,462
Sun	130
Moon	153
Mercury	85
Venus	106
Mars	24
Jupiter	15
Saturn	18
Uranus	18
Neptune	11
Nova Persei	9
Screen stars	318
Astronomische Gesellschaft Zone stars	619
Astronomische Gesellschaft Zero stars	201
Zodiacal Zone stars	1,022
Zodiacal Zero stars	191
Eros	33
Eros Zone stars	1,361
Eros Zero stars	434
Total observations	6,310

Very respectfully,

THEO I. KING,
In charge 9-inch Transit Circle.

The SUPERINTENDENT, NAVAL OBSERVATORY.

THE 6-INCH TRANSIT CIRCLE AND THE CLOCK VAULT.

SIR: From the beginning of the year until February 5 I was assisted by Assistant Astronomer F. B. Littell, who was then temporarily detached for duty in connection with the observation of the total solar eclipse of May 18, 1901. Computer George K. Lawton assisted as microscope reader and recorder from December 8, 1900, to March 7, 1901. Computer J. C. Hammond was detailed on June 7 for duty on the instrument, and has since that time been engaged in the reduction of the observations of the comparison stars for the Planet Eros.

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ASTRONOMICAL WORK.

The instrument has been in use on almost every clear night during five and a half months of the year in observing the fixed stars. During the remaining six and a half months repairs and special investigations for the removal of defects have been in progress.

The observations of 135 Comparison Stars for the planets which were not quite finished at the close of the last fiscal year were completed, with the exception of one small group, on July 16, 1900, and the remaining stars were observed during the period February 23 to March 7, 1901.

Observations on the Supplementary List of Comparison Stars for the Planet Eros were commenced by myself and Mr. Littell on December 8, 1900, and were finished on January 29, 1901. Observations of stars with wire screens for personal equation due to star magnitudes, and observations for thread intervals of the new spider-line reticule, furnished by Warner & Swasey in August, were made during October, November, and December, 1900.

A summary of observations made during the year follows:

OBSERVATIONS OF STARS.

Ephemeris stars for clock error	472
Polaris and 43 H Cephei for azimuth of mark	83
Zodiacal stars	307
Comparison stars for Eros	1,370
Thread interval stars	68
Screen stars for personal equation	402
Miscellaneous stars	23
Total number of observations of stars	2,725

DETERMINATIONS OF INSTRUMENTAL CONSTANTS.

Collimation	102
Level (by spirit level)	187
Level (by observations over mercury)	53
Azimuth of meridian mark	83
Azimuth of instrument from mark	347
Nadir point, Circle A	126
Nadir point, Circle B	130
Runs of microscopes	16
Total number of determinations of constants	1,044

The observations with screens for determination of personal equation due to star magnitudes indicate that Mr. Littell's personal equations due to that cause is somewhat larger than my own, and also that small errors exist in the observed times of transit across the separate threads of the reticule, due probably to defects in the illumination of the field.

The pivots of the instrument were investigated in October by means of the hanging level and also with the axial collimator. They were also measured with a spherometer caliper and were found to differ somewhat in size. Their irregularities in form are such as to cause small but appreciable errors in observations in right ascension.

REPAIRS AND ALTERATIONS IN INSTRUMENTS.

A 6½-inch lens of 185 feet focal length by Brashear, together with cast-iron brackets, for south meridian mark, has been furnished during

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the year by Warner & Swasey, of Cleveland, Ohio, but has not yet been put in place. The north meridian mark has been used during the year with some difficulty as it is not at, but several feet south of the principal focus of the lens through which it is viewed.

The apparatus for illuminating the field of the telescope has been, until recently, so defective as to cause serious error in transit observations. This is apparently due in some way to the fact that the light was reflected obliquely upon the reticule. A part of the original illuminating apparatus was removed and a small circular mirror, which throws the light perpendicularly on the reticule and parallel to the line of collimation, was cemented to the inner surface of the object glass. The illumination of the field is now entirely satisfactory. It is capable of the most delicate adjustment from total darkness to great brilliancy, and all parts of the field are equally bright. This improvement was made without expense to the Observatory.

The two divided circles were sent on April 24 to Warner & Swasey to be redivided, as the old divisions were unsatisfactory. These circles have not yet been returned.

The objectives of the microscopes used in reading the divided circles gave bad definition and on inspection were found to be visibly defective. New objectives have been furnished by Mr. J. A. Brashear.

The collimation and level constants of the instrument change very slowly and continue to be entirely satisfactory, but the large variation of azimuth with temperature mentioned in last year's report has been only partially removed. After various experiments, which gave only negative results, the heavy cast-steel bed-plates were reversed in position by turning each one horizontally on its own pier through 180°. The change of azimuth was then very much reduced in amount. These bed-plates were replaced on June 17 with new cast-iron bed-plates. The tests subsequently made indicate that the amount per degree of the variation of the azimuth with temperature is considerably reduced. The curve of azimuth change is simplified, and the response to changes of temperature is much slower, indicating probably that the remaining trouble lies in the massive marble piers or the manner in which they rest on their foundations. Each pier is supported on three pieces of cardboard about one-fourth of an inch thick. I recommend that the marble piers be replaced by piers built of brick laid in cement in accordance with the best modern practice.

THE CLOCK VAULT.

During January and February a clock vault, 8 feet square and 7 feet high, was built in the basement of the observer's room adjacent to the building which shelters the 6-inch transit circle. The construction of the vault is intended to be such that it will be practicable to keep the temperature within very nearly constant throughout the year. A 9-inch brick wall incloses a wooden house of dimensions above stated, with an air space of 1 foot, which contains hot-water pipes for heating. The whole is roofed over with boards inclosing a 6-inch layer of asbestus wool. The vault contains three brick piers for clocks and one small pier which may be used in mounting a pendulum apparatus for testing the minor irregularities of clock rates. Triple doors are provided and means for slow ventilation.

The location is on the summit of a hill, and drainage conditions are such that the basement in which the vault is situated is remarkably

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dry. There is little reason to fear damage from rust to the mechanism of the clocks, provided that ordinary care is exercised, even when the clocks are not protected by air-tight cases.

A clock by Kessels, which seems to be in excellent condition, has been mounted in the vault, inclosed in a heavy copper case which has been in the Observatory for some years and out of use. This case has been to some extent remodeled by the Instrument Maker, but all attempts to make it air-tight have been only partially successful. An air-tight case for the Howard clock, No. 404, is now being constructed by Mr. G. N. Saegmuller of Washington.

Very respectfully,

MILTON UPDEGRAFF,
Professor of Mathematics, U. S. N.

The SUPERINTENDENT, NAVAL OBSERVATORY.

THE 12-INCH EQUATORIAL.

SIR: I have the honor to submit the following report of work upon the 12-inch equatorial during the fiscal year ending June 30, 1901. The instrument was placed under my direction March 30, 1901. Prior to that time it was under the general charge of Professor S. J. Brown, U. S. N. It was dismounted in November, 1900, and a number of material changes in the clamps and tangent screws and in the head casting were effected by Mr. G. N. Saegmüller, the original maker of the instrument. These alterations were not entirely completed and the telescope ready for use until the latter part of April, although it had been used occasionally during March and April to give visitors a view of objects which could be picked up without the aid of the circles. The alterations have materially improved its efficiency, but there are still some minor changes possible which would greatly increase the ease of manipulation.

The constants of the instrument have been partly redetermined and a few observations undertaken of faint stars and double stars within the limits of the zone which was observed on the 9-inch transit circle for the Astronomische Gesellschaft. These are not yet completed. The double stars have been measured by Computer E. A. Boeger. Computer G. K. Lawton made one observation of Proserpina (26) on June 18, but completed the series on the 26-inch equatorial.

Very respectfully,

THEO I. KING,
In charge 12-inch Equatorial.

The SUPERINTENDENT, NAVAL OBSERVATORY.

THE PRIME VERTICAL TRANSIT AND THE 5-INCH ALT-AZIMUTH.

SIR: In compliance with paragraph 23 of the regulations governing the United States Naval Observatory, I respectfully submit the follow-

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ing report of the operations in my department during the year ending June 30, 1901.

Before proceeding to report upon the observations secured with the instruments I desire to invite the attention of the superintendent to the following extract from Science for January 11, 1901, page 42:

> We find, also, that the total number of separate observations with the prime vertical transit was 164, less than one-half the number of nights in the year, while those with the alt-azimuth, used as a zenith telescope, numbered a little more than the days in the year. At the international geodetic stations the observers are expected to make about 16 double observations on every clear night.

Attention is also invited to this extract from the same publication, but of date January 4, 1901, page 4:

> There are also intimations that something is wrong with the prime vertical transit, and altogether the impression made on the reader is that, after seven years of effort to equip the Observatory with the best instruments, it is doubtful whether a single one of real importance, except the great telescope, is in order for first-class work.

The writer of these editorials in Science clearly indicates that his conceptions of the amount of astronomical observing to be obtained with an instrument in the prime vertical are absurd.

Taking up the first extract, I wish to answer it. I was, by orders of the Department, as well as by yourself, detailed last spring as an observer in one of the parties sent south to observe the eclipse of the sun, and for six weeks I was detached from the instrument.

From April 15 to May 1 I was directed to give my whole time to preparing for shipment the apparatus to be used in the eclipse. From May 1 until June 1, 1900, I was at Griffin and Barnesville, Ga., engaged in preparing for the phenomena just mentioned. In addition, I observed at both places on fifteen nights, to determine their latitude and longitude.

The wisdom of the Observatory displayed in having those two fundamental positions determined is well illustrated by the misfortune that came to an observer who went to Africa. He trusted to an approximate latitude and longitude, and found at the instant of the eclipse he was entirely outside of the shadow line.

If the writer of the above extract was only superficially informed of the time necessary to secure a complete observation of a star across the prime vertical, he would not have attempted to make a comparison between the number of observations secured during the same period with the prime vertical and the zenith telescope. It will take about four hours per night to observe sixteen pairs of stars with the zenith telescope, the number usually obtained by those engaged in the variation of latitude work. In the same time it is impossible for anyone using the prime vertical to secure more than four or five, and had the writer consulted an astronomer he would have found that out.

During the past spring I observed practically all night on each night in which the sky was clear, and during an interval of nine or ten hours the largest number of star observations I could possibly obtain was nine or ten.

As an additional answer to this senseless criticism, I would invite the attention of the Superintendent to a comparison of the number of observations made with our instrument with that obtained by the only other astronomer who is now continuously observing with the prime vertical transit.

In 1900 I obtained in ten and one-half months observing 164 obser-

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vations. The observer at Pulkowa for the full year made 106. Since 1896 I have secured 1,150 observations. In the same time the prime vertical at Pulkowa has yielded 755. This record will be found in Professor Albrecht's report on the variation of latitude for 1900.

The remarks contained in the second extract are equally absurd.

In justice to our prime vertical transit, I desire here to state that it is of a better form, it is built in a more symmetrical manner, and its mounting permits of determining the errors it may have in a more complete manner than any other now in use.

In 1898 I obtained about 125 observations of α Lyrae in the full daylight, as well as in the night. The range between the greatest and least declination for the whole year's work, including every observation made, and the good, fair, and poor seeing that obtained for each, was 1.″44. If four observations are rejected, because they stand out so markedly from the others, made at a time when the seeing was very poor, and so noted in the observing book, the range is reduced to 1.″04.

There is not in existence a meridian circle, vertical circle, or zenith telescope that has been used to observe the same star or pair of stars, *throughout the year*, that has as small a range as this in the declination, or latitude, obtained with it. The probable error of a single observation for this series, including the variation of latitude, is $\pm$0.″16.

The prime vertical transit is in good order, and has been so since my last report.

I have continued observations by reflection over a basin of mercury, so as to keep a constant check upon the level correction. I give herewith the latitude of the instrument, secured from observations made direct and by reflection, upon dates that are within a very few days of each other. There is not a more critical test of the accuracy of the level correction obtained by the aid of a spirit level, as far as prime vertical observations are concerned, than that of comparing direct and reflected determinations.

An examination of these individual latitudes, as well as the mean of each set, clearly indicates that the level tube is a good one, and is free from systematic errors.

Latitude.						
Direct observations.				Reflected observations.		
	°	′	″	°	′	″
	+38	55	14.33	+38	55	14.50
			14.96			14.42
			14.76			14.50
			14.80			14.39
			14.67			15.03
			14.47			14.47
			14.62			14.81
			14.24			14.91
			14.65			14.60
			13.90			14.41
			14.56			14.83
			14.63			14.36
			14.43			14.85
			14.07			14.29
Mean	+38	55	14.54	+38	55	14.60

It will be noticed that these means differ by only 0.″06, and together by only 0.″07 from the general mean given below, which has been obtained from nearly 1,600 observations.

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During the year I have made an investigation of the form of the two pivots attached to the instrument. I have examined each throughout the length of its bearing surface in the Ys, and the results, which will be printed in the volume containing the observations secured with the instrument, do not indicate that either pivot is out of parallelism with the cube, or that their departure from a true cylinder is of enough magnitude to affect an observation.

In the past year I have made 619 observations with the aid of both instruments. The reductions of the observations, which have all been made by myself, are practically complete to the 1st of January, 1901.

Last fall I made a complete re-discussion of the prime vertical transit observations, basing the derived latitudes upon the star places obtained from the New Catalogue of Fundamental Stars, prepared by Prof. S. Newcomb. After it was finished the results were transmitted to Professor Albrecht, of the Central Bureau der Internationalen Erdmessung, Potsdam, Germany, to be used by him in his annual paper upon the "Variation of Latitude."

From that discussion the following mean yearly latitudes were obtained:

	°	′	″
1894	38	55	14.51
1895			.52
1896			.61
1897			.46
1898			.45
1899			.43
1900			.55
Mean	38	55	14.50
Reduction to the clock room			—.52
Latitude of Naval Observatory	38	55	13.98

The individual observations of all prime vertical transits up to December 31, 1899, are now ready for the printer. The introduction to the volume to contain them is three-fourths completed, and will be finished in time to transmit it to the Government Printing Office by the last of July or middle of August.

The 5-inch alt-azimuth was used during the year principally as a zenith telescope, in connection with the prime vertical transit. I am not making zenith-telescope observations exclusively with it, but only of those stars that are observed with the prime vertical, and which permit of being observed by Talcott's method.

This Observatory is the only one in this country equipped with a prime vertical transit, and for that very reason the major portion of the data we are securing for the study of the variation of latitude is made with it.

To keep a constant check upon the results of the first-mentioned instrument, to be able at all times to compare its working with the zenith telescope, has been the constant aim of this Observatory, and a comparison of observations for latitude from two methods of observing so unlike as obtains in these two instruments is bound to reveal any systematic errors existing in either, when quantities as small as those causing the change of latitude are to be measured.

I would respectfully bring to the attention of the Superintendent the need in this department of a computer employed at a moderate compensation. In addition to my observing, in the past all the reduc-

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tions of observations secured from both instruments have been made by myself. This year I find I am falling in arrears. Such an assistant would relieve me of a great deal of routine copying and computing, and permit me to investigate other problems in my work that demand attention, but which have not been taken up for want of time.

I would also invite his attention to the need of a mark for the prime vertical transit. One of the criticisms that has been made of the instrument is the absence of such a mark. This is a fair criticism, for the observer should at all times be able to determine the azimuth of the instrument, especially between the east and west transits of a star. Professor Hall in my presence suggested the necessity of it, and Professor Harkness had promised that before he retired he would mount the mark, but many other pressing needs came in and he left the Observatory before he was able to do so.

Respectfully submitted.

GEO. A. HILL,
Assistant Astronomer.

The SUPERINTENDENT, NAVAL OBSERVATORY.

THE 40-FOOT PHOTOHELIOGRAPH.

SIR: During the year photographs were made of the sun on 116 days. Sun spots were observed on them on 24 days, as follows: October, 13 days; November, 1 day; February, 5 days; May, 3 days.

This shows a very quiescent state of solar activity, the average number of spots being slightly less than the year preceding. Besides sun spots, the plates show many faculæ and fine detail in the granulation of the solar surface. This was rendered possible by the use of photographic plates, having a fine-grained lantern-slide emulsion, giving contrast and fine definition by the use of special developer.

Owing to my absence on duty with the Naval Observatory eclipse expedition to Sumatra, the daily record was kept by Computer E. A. Boeger from February 8 to the end of the fiscal year.

Respectfully,

GEO. H. PETERS,
Photographer in Charge.

The SUPERINTENDENT, NAVAL OBSERVATORY.

THE TOTAL SOLAR ECLIPSE OF MAY 18, 1901.

SIR: The appropriation for the observation of this eclipse became available early in January, 1901, thus affording very scant time for preparations, which were necessarily pushed to completion previous to February 1, when it was necessary to ship the instruments.

The expedition comprised the following persons:

Prof. A. N. Skinner, U. S. N., chief.
Prof. W. S. Eichelberger, U. S. N.
Assistant Astronomer F. B. Littell.
Photographer G. H. Peters.
Assistant L. E. Jewell.

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Assistant W. W. Dinwiddie.

In addition to the above members of the Naval Observatory staff the following scientists were invited to become members of the expedition:

Prof. E. E. Barnard, Yerkes Observatory.

Dr. W. J. Humphreys, University of Virginia.

Dr. N. E. Gilbert, Johns Hopkins University.

Dr. S. A. Mitchell, Columbia University.

Mr. H. D. Curtis, University of Virginia.

The place of observation selected was the west coast of Sumatra, in the vicinity of Padang. Arrangements were made for the transportation of the expedition from San Francisco to Manila on an army transport and from Manila to Padang, Sumatra, on a United States war vessel to be designated by the commander in chief of the Asiatic Station.

The instruments were shipped by fast freight to San Francisco January 26, where they arrived February 13. The eclipse party left Washington February 5 to 7 and arrived in San Francisco February 10 to 12. The instruments having been placed on board, the expedition sailed on the U. S. army transport *Sheridan* February 16. The *Sheridan* arrived at Honolulu February 25; sailed from Honolulu February 28 and arrived at Manila March 18, after a prosperous and uneventful voyage.

Admiral Remey, commander in chief of the Asiatic Station, designated the U. S. S. *General Alava*, Lieutenant-Commander Halsey commanding, to convey the expedition from Manila to Padang, Sumatra. The equipment having been transferred from the *Sheridan* to the *General Alava*, the expedition sailed from Manila March 26, proceeded direct through the Straits of Sunda and arrived at Emma Haven, the port of Padang, 7 kilometers distant, on April 4. The eclipse party was first greeted by the United States consular agent, Cornelius G. Veth, who rendered invaluable assistance in placing the party in communication with the officials of the Netherlands Government. Aid was freely granted in numberless ways by Governor Joekes and his subordinates thoughout the island. It should be specially noted that free transportation was granted over the entire railway system for the members of the expedition and for the instrumental outfit, weighing about 15 tons.

The three stations for observation selected by Professor Skinner were Fort de Kock, situated near the northern edge of the shadow, Solok and Sawah Loento, two points where the railroad in the interior runs nearest the central line of the shadow. The distances of these stations by rail from Emma Haven are, respectively, Fort de Kock, 94 kilometers; Solok, 128 kilometers; and Sawah Loento, 156 kilometers.

At the request of Professor Skinner the expedition received valuable assistance from Ensign Gilbert Chase, Cadet W. V. Tomb, U. S. N., and Asst. Surg. H. E. Odell, officers of the *General Alava*. Through the courtesy of Lieutenant-Commander Halsey the expedition was favored with the assistance of eight men from the *General Alava*, viz: A. L. Smith, W. A. Vanaken, R. H. Schops, M. C. Suman, J. J. Few, W. J. Cassidy, C. W. Keeter, and G. H. Getz, who rendered most efficient service, which is worthy of mention.

The expedition received valuable volunteer assistance from Mr. G. E. Irving, agent of the British and Foreign Bible Society, Mr. René Granger, of Cartersville, Ga., and Mr. Melvin Munson, of Padang.

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The distribution of the instruments, observers, and assistants was as follows:

FORT DE KOCK STATION.

[In charge of Prof. W. S. EICHELBERGER, U. S. N.]

1. Thirty-foot concave grating spectroscope, in charge of Dr. W. J. Humphreys. This grating is the property of Mr. L. E. Jewell.

2. Photoheliograph of 5 inches aperture and 39 feet focal length, in charge of Photographer G. H. Peters, assisted by A. L. Smith.

These two instruments were fed by a Brashear coelostat, furnished with two 10-inch silver-on-glass mirrors especially built for the Naval Observatory for such work.

SOLOK STATION.

[In charge of Prof. A. N. SKINNER, U. S. N.]

1. Photoheliograph of 6 inches aperture and 61.5 feet focal length, in charge of Prof. E. E. Barnard. This instrument was fed by a coelostat furnished with a silver-on-glass mirror 15 inches in diameter. The objective and coelostat are the property of the Yerkes Observatory.

2. Ten-foot concave grating spectroscope, in charge of Mr. L. E. Jewell, assisted by R. H. Schops.

3. Flat-grating spectroscope used with a slit, in charge of Assistant Astronomer F. B. Littell. This grating is the property of the Johns Hopkins University.

4. Prismatic camera, in charge of Assistant W. W. Dinwiddie. The 60° flint-glass prism has faces about 6 inches square; the telescope employed with it has an object glass 6 inches in aperture and 7.5 feet focal length. The prism and object glass are the property of the Smithsonian Institution.

5. Spectropolarigraph devised and furnished by Prof. R. W. Wood, of Madison, Wis., now of Johns Hopkins University; in charge of Dr. N. E. Gilbert, assisted by J. J. Few.

6. Photoheliograph, 7.5 inches in aperture and 114 inches focal length, in charge of Mr. H. D. Curtis.

7. Voigtlaender doublet, 6.25 inches in aperture and 31 inches focal length.

8. Clark doublet, 3.25 inches in aperture and 30 inches focal length.

Nos. 7 and 8, which are the property of the Yerkes Observatory, were mounted by Mr. H. D. Curtis on a 6-inch equatorial stand loaned by Mr. G. N. Saegmuller. They were placed in charge of Mr. G. E. Irving, assisted by W. J. Cassidy and G. H. Getz.

Instruments 2, 3, 4, and 6 were fed by modified coelostats originally constructed for transit of Venus work.

SAWAH LOENTO STATION.

[In charge of Dr. S. A. MITCHELL.]

1. Flat grating spectroscope in charge of Dr. S. A. Mitchell, assisted by C. W. Keeter.

2. Photoheliograph, 6 inches in aperture and 104 inches in focal length, in charge of Mr. René Granger.

In brief, the results obtained were as follows:

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At Fort de Rock, on the day of the eclipse, the sky was perfectly clear, thus permitting Mr. Peters, with the photoheliograph, to secure ten negatives, and Dr. Humphreys, with the 30-foot concave grating, six photographic spectra. Professor Eichelberger observed the times of the first, second, and third contacts.

At Solok Professor Skinner was able to observe the times of the first, second, and fourth contacts; but clouds, more or less dense, prevented securing photographic negatives of any value.

At Sawah Loento the clouds were somewhat less dense than at Solok. Mr. Granger secured six negatives with the photoheliograph, and Dr. Mitchell six photographic spectra with the flat grating.

An interesting incident of the stay in Solok was the sudden appearance of a naked-eye comet, which was first seen by Mr. W. W. Dinwiddie in the western sky shortly after sundown on May 3. Mr. Curtis and Professor Barnard secured several photographs of the comet May 5 and 6.

It should be especially noted that the utmost generosity was displayed by all the officials of Sumatra in freely affording assistance to the expedition at every opportunity.

After the eclipse the negatives were promptly developed. The equipment was packed, shipped by rail to Emma Haven, and placed in the hold of the *General Alava*, on board of which the expedition sailed for Manila May 28. The *General Alava* touched at Tandjong Priok, the port of Batavia, May 31, sailed therefrom June 1, and arrived at Manila June 8.

By authority of Admiral Rodgers, at Manila, the instruments were transferred to the U. S. S. *Culgoa* and shipped to the United States via Suez.

Transportation for Messrs. Gilbert and Humphreys was furnished from Manila to San Francisco on board the U. S. army transport *Meade*, which was billed to sail from Manila July 1. Transportation for the remainder of the party was obtained on board the U. S. chartered transport *Indiana*, which sailed from Manila, after some days' delay, on June 20 and proceeded without stop to San Francisco, where she arrived July 16. From San Francisco the members of the expedition proceeded to their destinations by rail.

Very respectfully,

A. N. SKINNER,
Professor of Mathematics, U. S. N.,
In charge Expedition.

The SUPERINTENDENT, NAVAL OBSERVATORY.

REPORT OF COMPUTING BUREAU.

SIR: I have the honor to submit the following report of computations during the fiscal year ending June 30, 1901. The Computing Bureau was established September 12, 1900, under charge of Professor W. S. Eichelberger; during Professor Eichelberger's trip to Sumatra, beginning February 7, 1901, Assistant Astronomer Theo I. King supplied his place. The force engaged upon the work were Computers W. M. Brown, E. A. Boeger, G. K. Lawton, and J. C. Hammond; Mr. A. B. Turner, July 11 to August 23, 1900; Mr. W. W. Dinwiddie,

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July 17 to August 31, 1900; Mr. J. A. Lyon, July 18 to August 24, 1900; Misses E. A. Lamson and C. M. Upton, from July 21, 1900; Mr. Roy Y. Ferner, from August 2, 1900; Mr. E. I. Yowell, from February 6, 1901; Mr. H. R. Morgan, from March 26, 1901; Mr. C. W. Frederick, from April 2, 1901; and Miss C. C. Barnum, from April 4, 1901.

During the year Volume I, Second Series, "Publications of the United States Naval Observatory, Sun, Moon, Planets, and Miscellaneous Stars, 1894–1899," has been completed and published. The reduction of subsequent observations is also practically up to date. The Zone, $-13^\circ\ 50'$ to $-18^\circ\ 10'$, is designed to constitute Volumes II and III. For this the printer's copy, covering the observations to 1900, is completed. The remaining observations already made are reduced, and the issue of the two volumes is confidently looked for before the close of the year 1901.

In accordance with the statements in the introduction of Volume I, and on page 24 in the "Report of the Superintendent for the year ending June 30, 1900," the volumes of the new series will be classified, and each one will contain only the material pertaining to its title. The observations of Eros and comparison stars made during the past twelve months should make Volume IV. This material has been completely reduced, and is ready for the printer.

Considerable progress has been made in reducing the observations of Zodiacal stars by Professor Eichelberger.

The order creating the computing bureau reads as follows:

BUREAU OF REDUCTIONS.—A computing bureau is established, under charge of Professor Eichelberger, to which all computers are assigned, and they shall report to the officer in charge of that bureau, except when especially assigned to other duties. The object of this bureau is to relieve the individual observer from routine reductions, thus giving him time while not observing for the discussion of his instrument and the results of his observations. Whenever pieces of computing are available on any of the instruments, they will be reported to the Astronomical Director for consignment to this bureau.

The bureau has established its utility, and I would recommend the enlargement of this order to include the custody of all observations, records, and computations. I think a place for this matter should be provided, adapted for its preservation and for rendering it easily accessible.

Very respectfully,

THEO I. KING,
In charge Computing Bureau.

The SUPERINTENDENT, NAVAL OBSERVATORY.

REPORT OF THE DIRECTOR OF THE NAUTICAL ALMANAC.

UNITED STATES NAVAL OBSERVATORY,
NAUTICAL ALMANAC OFFICE,
Washington, D. C., August 31, 1901.

SIR: I have the honor to submit the following report of the operations of the Nautical Almanac Office for the fiscal year ending June 30, 1901:

PRINTING.

The books published during the year were received from the Government Printing Office on the following dates:

The Pacific Coaster's Nautical Almanac for 1901, first edition, October 2, 1900;

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The American Ephemeris and Nautical Almanac for 1901, second edition, December 22, 1900;
The American Nautical Almanac for 1901, third edition, February 8, 1901;
The American Nautical Almanac for 1904, first edition, March 15, 1901;
The American Ephemeris and Nautical Almanac for 1904, first edition, April 20, 1901;
The American Nautical Almanac for 1902, second edition, May 22, 1901.

DISTRIBUTION OF PUBLICATIONS.

During the fiscal year ending June 30, 1901, the sale and distribution of publications were as follows:

Title.	Sold.	Distributed.	Bureau of equipment.	Public service.	Total.
American Ephemeris	963	249	60	562	1,834
American Nautical Almanac	3,251	24	33	326	3,634
Pacific Coaster's Nautical Almanac	1,826	0	10	14	1,850
Astronomical Papers	106	48	1	44	199

The proceeds of the above sales amounted to $2,379.48, and, in compliance with law, that money has been deposited to the credit of the Treasurer of the United States on account of public printing and binding.

THE AMERICAN EPHEMERIS.

While the law authorizing the publication of the American Ephemeris provides for the issue of each volume three years in advance of its date, yet that for 1904 was issued the latter part of April, 1901, or nearly four months late. A systematic redistribution of the office force, while not interfering with the new investigation now in progress, will prevent this delay in the future.

The general arrangement and plan of the Ephemeris, with a few minor changes, remain the same as in the volume for 1904. Struve and Peter's constants have been used in the main body of the work to secure uniformity with preceding volumes. The data which can not be thoroughly checked by differences has been computed in duplicate.

NEW INVESTIGATIONS.

The wide divergence between observations and tabular places from Damoiseau's tables has shown the desirableness of forming new tables of Jupiter's satellites. This work, which it is hoped may be finished in five or six years, has been commenced and will be pushed as rapidly as the regular work on the Ephemeris will permit.

The work of determining new elements of the inner satellite of Uranus has been completed.

The catalogue of Zodiacal stars prepared for use in this office in computing occultations, is so far advanced that the data contained in this catalogue are available for use in computing the occultations for 1905.

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MISCELLANEOUS.

Through the courtesy of the Superintendent of the Naval Observatory, facilities have been furnished to refit the library and permit of the proper classification of the volumes.

A card-index system for cataloguing the library and briefing the correspondence has been installed.

More than 30,000 volumes of the publications of this office, which have lain in the basement for years, have been securely tied in packages and placed upon shelves.

The original computations of the Astronomical Papers will be placed in the library, classified, and properly indexed.

I desire to invite attention to the efficiency of the assistants in this office, who are, without exception, graduates of leading universities of America and Europe, and I do not consider it inappropriate to say that their salaries are entirely inadequate to the duties required of them.

Very respectfully,

WALTER S. HARSHMAN,
Professor of Mathematics, U. S. N.,
Director Nautical Almanac.

The SUPERINTENDENT, NAVAL OBSERVATORY.

DEPARTMENTS OF NAUTICAL INSTRUMENTS AND OF GENERAL STOREKEEPER.

SIR: The preparation of requisitions for the purchase of instruments, supplies, etc., and for necessary repairs to old instruments, for issue to ships, navy-yards, and naval stations, has been continued in the Department of General Storekeeper.

The following table shows the number of instruments and articles purchased, and the number issued in the regular routine business for the fiscal year ending June 30, 1901:

Stores received and issued by General Storekeeper's Department.

Instruments, supplies, etc.	Received.	Issued.
Artificial horizons	0	22
Sextants:		
High-grade	19	36
Squadron angles	0	7
Hydrographic	168	133
Spare glass for	0	68
Octants	9	36
Parallel rulers:		
Sigsbee	0	3
Ordinary	125	65
Clocks:		
Deck	30	58
No. 2	83	51
Boat	112	95
Protractors, three-arm	60	69
Drawing instruments, boxes	39	67
Dividers, navigator's	47	44
Tapes, steel	39	23

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Stores received and issued by General Storekeeper's Department—Continued.

Instruments, supplies, etc.	Received.	Issued.
Thermometers:		
Maximum and minimum	72	0
Air and water	226	365
Psychrometers	25	27
Spyglasses:		
Low-power	68	48
Medium-power	19	32
High-power	62	57
Officer of deck	145	52
Binoculars:		
Day	263	135
Night	227	153
Barometers, aneroid	66	54
Clinometers, Hicks	0	16
Reading glass, captain's	38	35
Splines and weights	49	22
T-squares	19	3
Magnetometers	2	2
Dip circles	2	2
Transit, surveyor's	0	13
Theodolites	8	20
Patent star finder	1	0
Course indicator	1	0
Barograph	1	1

The aggregate value of instruments and stores purchased, not including those received from navy-yards and other sources, amounted to $49,100.93 during the year.

The number of regular shipments during the year was 168, and the invoiced value amounted to $43,864.46.

Shipment has been made of the 6 complete outfits for hydrographic survey in the Philippine Islands, of the 4 additional outfits for hydrographic work, and of the 2 outfits for the telegraphic determination of longitude assembled during the previous year.

In addition to the above ordinary work the assembling and inspection of 4 more survey outfits and 2 more outfits for telegraphic determination of longitude have been almost completed during the year. One of the longitude outfits has been shipped.

The value of a survey outfit is $3,450.82, approximately, and the value of a longitude outfit is $3,658.60, approximately, giving a total for the 18 outfits of $62,945.88. All the outfits have been purchased under the appropriation "Ocean and Lake Surveys."

As will be easily seen this additional work has been considerable, and the department has suffered no little inconvenience by the temporary detachment of the officer in charge.

M. E. PORTER, *Computer.*

The SUPERINTENDENT, NAVAL OBSERVATORY.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

SIR: During the year 14 standards and 4 hacks, which were purchased with ships during the Spanish war, have been reported to the Observatory. One hack which was captured has been repaired and is now ready for issue. A competitive trial for the purchase of new chronometers was held. Seventeen chronometers were entered, and of these 9 were purchased.

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The following table shows the present location of all the seagoing chronometers belonging to the Navy:

	In service afloat.	At Mare Island.	At shore stations.	Ready for issue.	Undergoing repairs.	Total.
M. T. standards	2650	14	15	32	28	354
M. T. hacks	8	7	19	2	3	111
M. T. break circuits	2	0	6	0	1	9
Sid. break circuits	6	1	4	1	3	15
Sid. standards	0	1	0	1	0	2
Thermometric	0	0	0	2	2	4
Pocket	0	0	0	5	1	6
Total	353	23	44	43	38	501

The following table includes the chronometers at Mare Island, Cal., in addition to the same for the Observatory, and shows the number received and issued during the year:

	Purchased.		Returned from—			Condemned to be hacks.	Converted from standards.	Issued to—			Condemned to be hacks.	Converted from standards.
	New.	With ships.	Ships.	Shore stations.	Makers.			Ships.	Shore stations.	Makers.		
M. T. standards	9	14	38	6	40	0	0	84	1	36	5	1
M. T. hacks	0	5	11	0	7	5	0	25	0	6	0	0
M. T. break circuits	0	0	0	1	0	0	1	1	1	1	0	0
Sid. break circuits	0	0	1	3	4	0	0	4	2	3	0	0

On August 14, 1900, a requisition was made for the purchase of 12 standard chronometers after a competitive trial, and notice was sent to the principal firms of chronometer makers in the United States.

Three firms entered chronometers in the competitive trial. Wm. Bond & Son entered 8, C. A. Geissler entered 6, and T. S. & J. D. Negus entered 3.

One chronometer, Bond 563, passed trial with a trial number of 8.3, and was purchased, according to specifications, for $350. Four chronometers—Bond 566 and 552, and Negus 1875 and 1884—passed with trial numbers between 9 and 16. These were purchased at $330 each. Four chronometers—Geissler 1061, Bond 555 and 562, and Negus 1905—had trial numbers between 16 and 25. These were purchased, with the consent of the Bureau of Equipment, at $300 each.

Twenty of the Bureau's chronometers were subjected to the same trial for the determination of new rate curves.

The temperature trial began January 4 and ended March 30. The chronometers were then placed in the chronometer room and run for twelve weeks.

The apparatus for regulating the temperature operated satisfactorily.

The following table shows the detail results of the trial:

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Relative number.	Time / Temperature, Fahrenheit (degrees) / Relative humidity (per cent)	Repaired by—	Chronometer No.	Maker.	Dec. 28 to Jan. 4.	Jan. 7 to Jan. 14.	Jan. 18 to Jan. 25.	Jan. 29 to Feb. 5.	Feb. 7 to Feb. 14.	Feb. 21 to Feb. 28.	Mar. 2 to Mar. 9.	Mar. 12 to Mar. 19.	Mar. 23 to Mar. 30.	Apr. 4 to Apr. 11.	Apr. 11 to Apr. 18.	Apr. 18 to Apr. 25
	Temperature, Fahrenheit (degrees)				90.0	85.0	69.8	54.9	45.7	55.0	69.7	85.1	90.0	66.6	66.0	70.4
	Relative humidity (per cent)				69	68	71	66	72	70	70	71	68	58	64	58
1	Time	Bliss	3668	T. B. Winter & Son	+1.30	+0.64	+0.61	+0.33	+0.57	+1.00	+0.96	+0.99	+0.51	−0.19	−0.21	−0.06
2		Negus	1298	T. S. & J. D. Negus	+2.24	+1.19	+0.66	+1.33	+2.76	+1.23	+0.43	+1.26	+1.86	+0.81	+0.99	+0.63
3		Heinrich	1021	H. H. Heinrich	+1.96	+1.53	+0.47	+0.21	+0.46	+0.39	+0.39	+1.53	+1.94	+0.81	+0.70	+0.89
4		Bond	2087	Dent	+5.13	+4.04	+2.89	+3.14	+4.29	+3.46	+3.29	+4.23	+4.56	+2.43	+2.51	+2.60
5		Negus	1343	T. S. & J. D. Negus	+0.99	+0.54	−0.56	−0.43	+0.69	−0.27	−0.70	+0.13	+0.61	−1.26	−1.33	−1.59
6		do	1595	do	+1.99	+1.70	+0.90	+1.67	+3.07	+1.79	+1.03	+1.83	+2.40	+1.29	+1.30	+1.03
7		do	1234	do	+1.33	+1.44	+0.47	+0.86	+1.90	+0.64	+0.13	+1.20	+1.96	+0.53	+0.37	+0.34
8		do	1777	do	+2.37	+2.84	+1.87	+1.90	+2.66	+1.94	+2.10	+3.36	+3.69	+2.74	+2.70	+2.89
9		do	1305	do	+2.70	+2.90	+2.06	+2.79	+3.71	+2.39	+1.54	+2.46	+3.34	+2.24	+2.21	+1.94
10		Bliss	454	Hutton	+0.63	+0.14	−0.10	+0.89	+2.11	+0.91	−0.03	+0.39	+0.73	+0.86	−0.20	+1.10
11		Bond	49457	Dent	−1.34	−1.51	−0.99	−0.11	+0.61	+0.26	−0.29	−0.84	−1.76	−0.11	+0.06	+0.26
12		Bliss	2149	John Bliss & Co	+0.56	−0.07	−0.94	+0.19	+1.60	+0.29	−0.63	+0.09	+0.36	+0.76	+0.13	+0.44
13		Negus	1300	T. S. & J. D. Negus	+2.37	+2.14	+1.80	+3.33	+4.80	+3.36	+2.07	+1.81	+2.59	+1.74	+2.23	+1.56
14		Bond	549	Wm. Bond & Son	+0.46	+1.04	+0.80	+1.64	+2.69	+1.79	+0.96	+1.77	+2.16	+0.57	+0.51	−0.01
15		Negus	1464	T. S. & J. D. Negus	+2.13	+2.61	+1.63	+2.23	+3.58	+1.71	+0.70	+1.59	+2.33	+1.80	+1.70	+1.53
16		do	1120	do	+3.17	+2.23	+1.29	+1.79	+3.07	+1.34	+0.50	+0.77	+1.51	+1.13	+1.06	+0.80
17		do	997	do	−0.01	+0.10	−0.39	+0.93	+2.33	+0.83	−0.61	−0.27	+0.26	+0.27	+0.54	−0.23
18		Bliss	2803	John Bliss & Co	−0.87	−1.31	−1.70	−0.36	+1.14	−0.70	−2.46	−2.27	−1.89	−2.41	−2.97	−3.44
19		do	7364	Roberts	+0.49	−0.24	−2.17	−0.67	−0.57	−1.54	−2.21	−0.69	+0.33	−0.99	−1.00	−1.49
20		Bond	295	Wm. Bond & Son	+3.91	+3.90	+1.80	+0.86	+0.96	+0.21	+1.00	+3.54	+5.73	+3.36	+3.13	+3.34
1			563	Wm. Bond & Son	+0.87	+0.33	−0.33	−0.29	+0.13	−0.07	−0.54	+0.09	+0.46	−0.83	−0.83	−0.94
2			566	do	+2.63	+2.71	+2.64	+3.09	+3.87	+3.13	+2.04	+2.34	+3.27	+1.89	+1.99	+1.81
3			1875	T. S. & J. D. Negus	+0.37	+0.33	−0.17	+0.59	+1.83	+0.60	−0.16	+0.44	+0.80	+0.11	+0.11	−0.11
4			552	Wm. Bond & Son	+2.14	+1.83	+0.79	+0.26	+0.83	+0.49	+0.46	+1.87	+2.61	+0.27	+0.09	+0.31
5			1884	T. S. & J. D. Negus	+3.17	+2.76	+1.94	+2.07	+3.26	+2.10	+1.63	+2.59	+3.36	+1.31	+1.60	+0.91
6			1061	C. A. Geissler	+0.87	+0.41	−0.63	−0.39	+0.70	−0.29	−1.04	+0.19	+0.89	−0.99	−0.94	−1.11
7			555	Wm. Bond & Son	+3.06	+3.19	+2.21	+1.83	+2.57	+1.86	+1.89	+3.34	+4.23	+1.34	+1.23	+1.31
8			562	do	−1.33	−1.59	−1.33	+0.24	+2.50	+0.43	−1.43	−1.63	−1.27	−0.97	−0.90	−1.23
9			1906	T. S. & J. D. Negus	+2.58	+2.50	+1.37	+1.83	+2.83	+1.66	+0.84	+1.44	+2.01	+0.60	+0.44	+0.24
10			1059	C. A. Geissler	−0.69	−0.93	−2.01	−2.29	−1.97	−2.71	−2.51	−1.40	−1.86	−2.07	−2.29	−2.27
11			1049	H. H. Heinrich	+1.56	+1.11	+0.51	−0.14	+2.19	+0.60	+0.27	+1.26	+1.66	−0.34	−0.94	−0.40
12			1047	do	−1.57	−1.00	−1.91	−1.50	+1.07	−1.76	−2.76	−1.53	−0.87	−1.30	−1.23	−1.76
13			1048	do	+2.80	+3.29	+2.17	+3.26	+3.96	+1.86	+2.21	+3.50	+3.80	+2.16	+1.77	+1.17
14			511	Wm. Bond & Son	+1.94	+2.44	+1.89	+1.71	+5.09	+2.36	+1.24	+1.94	+2.73	−0.30	−0.49	−0.69
15			559	do	−0.14	−0.67	−1.79	+0.39	+1.91	+0.06	−1.54	−1.31	−1.00	−0.39	−0.81	−1.61
16			565	do	+0.91	+1.57	+0.64	−0.50	−0.29	−0.69	−0.11	+0.76	+0.73	+0.07	+0.14	+0.21
17			1046	H. H. Heinrich	+1 17	+0.86	+1.50	+3.41	+5.54	+3.84	+1.41	+2.53	+2.04	+0.13	+1.06	+1.17

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Relative number.	Repaired by—	Chronometer No.	Maker.	Apr. 25 to May 2.	May 2 to May 9.	May 9 to May 16.	May 16 to May 23.	May 23 to May 30.	May 30 to June 6.	June 6 to June 13.	June 13 to June 20.	June 20 to June 27.	Temperature of compensation.	Temperature constant.	Trial number.
Time															
Temperature, Fahrenheit ..... degrees.				72.3	69.9	67.3	67.2	67.2	66.7	70.4	74.0	75.2			
Relative humidity ..... per cent.				52	55	64	66	70	67	72	74	75			
1	Bliss.....	3668	T. B. Winter & Son	0.00	−0.23	−0.41	−0.33	−0.77	−0.53	−0.33	−0.16	+0.03	84.7	−0.00018	9.3
2	Negus	1298	T. S. & J. D. Negus.....										70.3	+0.00316	13.7
3	Heinrich .	1021	H. H. Heinrich	+1.03	+0.56	+0.59	+0.64	+0.30	+0.31	+0.50	+0.23	+0.53	60.3	+0.00209	14.2
4	Bond	2087	Dent	+2.79	+2.59	+2.44	+2.64	+2.36	+2.54	+2.76	+2.76	+2.96	65.0	+0.00273	14.7
5	Negus	1343	T. S. & J. D. Negus.....	−1.33	−1.56	−1.56	−1.53	−1.64	−1.53	−1.24	−1.24	−0.90	65.8	+0.00278	15.0
6	.....do	1595	.....do	+1.21	+1.04	+0.99	+0.93	+0.66	+0.74				69.9	+0.00347	15.3
7	.....do	1234	.....do	+0.39	+0.30	+0.13	+0.14	+0.01	+0.00	0.00	+0.01	+0.13	67.1	+0.00323	16.5
8	.....do	1777	.....do	+3.07	+3.01	+2.69	+2.54	+2.33	+2.33	+2.67	+2.80	+3.03	61.5	+0.00232	22.5
9	.....do	1305	.....do	+1.91	+1.96	+1.73	+1.64	+1.50	+1.44	+1.43	+1.47	+1.50	69.6	+0.00371	22.8
10	Bliss.....	454	Hutton	+0.06	−0.26	−0.31	−0.17	−0.36	−0.24	−0.27	−0.36	−0.11	73.7	+0.00287	23.5
11	Bond	49457	Dent	+0.20	−0.19	−0.56	−0.71	−1.07	−1.24	−1.03	−1.39	−1.43	127.3	+0.00037	24.1
12	Bliss.....	2149	John Bliss & Co	+0.63	+0.51								71.0	+0.00400	24.4
13	Negus	1300	T. S. & J. D. Negus	+1.00	+1.36	+0.97	+0.93	+0.86	+0.74	+0.76	+0.91	+0.99	77.0	+0.00324	25.3
14	Bond	549	Wm. Bond & Son	+0.06	+0.24	−0.13	−0.29	−0.39	+0.21	+0.21	−0.06	+0.47	71.7	+0.00305	29.5
15	Negus	1464	T. S. & J. D. Negus.....	+1.41	+1.36	+1.33	+1.36	+1.21	+1.20	+1.20	−1.13	+1.29	69.5	+0.00385	34.9
16	.....do	1120	.....do										70.3	+0.00282	40.0
17	.....do	997	.....do										73.9	+0.00405	40.2
18	Bliss.....	2803	John Bliss & Co	−3.80	−3.83	−3.60	−3.24	−3.14	−3.10	−3.36	−3.37	−3.37	75.1	+0.00412	44.9
19	.....do	7364	Roberts.....	−1.51	−1.61	−1.81	−1.96	−2.20	−2.24	−2.30	−2.30	−2.16	68.3	+0.00625	55.7
20	Bond	295	Wm. Bond & Son	+3.13	+2.89	+2.59	+1.50	+1.36	+1.27	+1.20	+1.16	+0.96	53.2	+0.00316	70.8
1	.....	563	Wm. Bond & Son	−0.93	−1.13	−1.13	−1.14	−1.21	−1.10	−0.79	−0.63	−0.47	66.8	+0.00200	8.4
2	.....	566	.....do	+1.81	+1.77	+1.84	+1.69	+1.64	+1.80	+1.64	+1.51	+1.56	74.8	+0.00210	13.2
3	.....	1875	T. S. & J. D. Negus	−0.09	−0.11	−0.13	−0.14	−0.57	−0.59	−0.44	−0.61	−0.49	71.3	+0.00288	13.5
4	.....	552	Wm. Bond & Son	+0.41	+0.39	+0.47	+0.47	+0.36	+0.40	+0.47	+0.47	+0.79	58.7	+0.00219	13.5
5	.....	1884	T. S. & J. D. Negus	+1.20	+1.17	+1.04	+1.19	+1.23	+1.31	+1.43	+1.44	+1.47	66.3	+0.00260	15.5
6	.....	1061	C. A. Geissler	−1.09	−1.26	−1.24	−1.24	−1.29	−1.24	−1.24	−1.31	−1.11	67.1	+0.00359	17.3
7	.....	555	Wm. Bond & Son	+1.33	+1.24	+1.19	+1.19	+0.93	+0.87	+1.03	+1.01	+1.17	59.1	+0.00215	17.4
8	.....	562	.....do	−1.44	−1.33	−1.24	−1.17	−1.14	−1.03	−1.27	−1.31	−1.30	79.6	+0.00338	22.0
9	.....	1906	T. S. & J. D. Negus	+0.24	+0.13	+0.16	+0.21	+0.01	+0.14	+0.19	+0.21	+0.40	68.9	+0.00353	25.0
10	.....	1059	C. A. Geissler	−2.73	−2.83	−3.10	−3.03	−2.64	−3.59	−2.97	−2.99	−2.94	58.1	+0.00189	35.2
11	.....	1049	H. H. Heinrich	−0.59	−0.83	−1.30	−1.26	−0.10	+0.23	+0.53	+0.70	+0.81	58.5	+0.00139	42.5
12	.....	1047	.....do	−2.16	−2.11	−2.24	−2.17	−2.21	−2.06	−2.26	−2.30	−2.16	68.5	+0.00393	44.6
13	.....	1048	.....do	+1.93	+1.66	+1.69	+1.69	+1.26	+1.57	+1.04	+1.23	+1.41	66.0	+0.00347	45.3
14	.....	511	Wm. Bond & Son	−1.16	−1.40	−1.66	−1.47	−1.41	−0.90	−0.49	+0.11	+0.41	68.9	+0.00244	49.6
15	.....	559	.....do	−1.66	−1.69	−1.87	−1.97	−2.00	−2.10	−2.41	−2.57	−2.67	73.5	+0.00572	58.3
16	.....	565	.....do	+0.37	+0.31	+0.06	−0.11	−0.71	−0.81	−0.50	−0.63	−0.40	722.5	.....	71.6
17	.....	1046	H. H. Heinrich	+0.84	+1.10	+1.33	+1.19	+1.43	+1.90	+2.47	+2.59	+2.03	75.9	+0.00540	91.4

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WATCHES.

The following table shows the number of watches issued and received:

	Issued.	Purchased.	Returned.	Repaired.	On hand.	Held for repairs.
Comparing	27	19	7	25	40	2
Stop	44	67	8	9	39	6
Torpedo boat	3	1	0	1	0	0

THERMOMETERS.

During the year 37 maximum and minimum thermometers have been issued, and 48 are now ready for issue. Four have been returned from ships.

THE TIME SERVICE.

During the year 142 observations for time were made. The 3 standard clocks and the 2 clocks for transmitting noon signals have performed fairly well. Noon signals were sent out every day in the year except Sundays. The average error for the year of noon signals (seventy-fifth meridian time) was 0.13 seconds.

Very respectfully,

M. E. PORTER, *Computer.*

The SUPERINTENDENT, NAVAL OBSERVATORY.

MAGNETIC DEPARTMENT.

SIR: I have the honor to submit the following report of operations in the Magnetic Department during the fiscal year ending June 30, 1901. No effort has been made to obtain magnetic records, because the disturbances occasioned by the grounding of electric traction and light wires still exist. The plant has been twice inspected during the year, and is in good order. The clocks are regularly wound.

Very respectfully,

THEO I. KING,
In charge Magnetic Department.

The SUPERINTENDENT, NAVAL OBSERVATORY.

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REPORT

OF THE

SUPERINTENDENT

OF THE

UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1902.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

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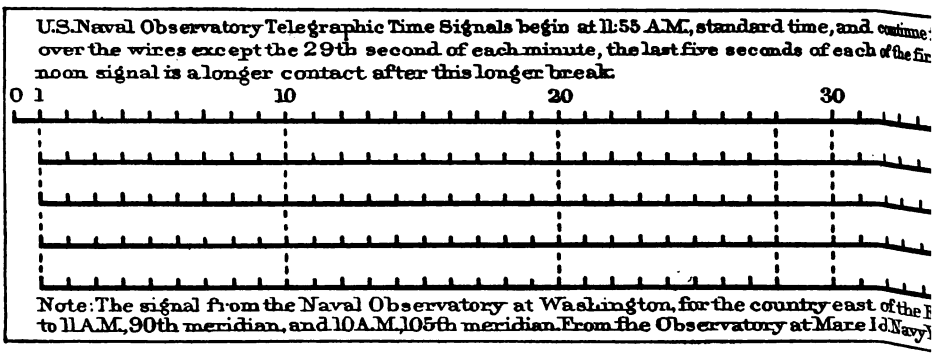
TELEGRAPHIC TIME

Sent out at Noon daily, except Sundays and Holiday

The entire series of noon signals sent out daily over the wires is shown gra signals as they would be recorded on a chronograph, where a pen draws a line it and is actuated by an electro-magnet so as to make a jog at every tick of th are such as to omit certain seconds, as shown by the breaks in the record. telegraph or telephone office to recognize the middle and end of each minute, e interval that is followed by the noon signal. During this last long interva and of clocks that are corrected electrically at noon throw their local lines corrects the clocks.


U.S. Naval Observatory Telegraphic Time Signals begin at 11:55 A.M., standard time, and continue over the wires except the 29th second of each minute, the last five seconds of each of the fir noon signal is a longer contact after this longer break.
0 1
10
20
30
Note: The signal from the Naval Observatory at Washington, for the country east of the R to 11 A.M., 90th meridian, and 10 A.M., 105th meridian. From the Observatory at Mare Id. Navy

This series of noon signals is sent continuously over the wires all ov preceding noon. For the country east of the Rocky Mountains the signals of the 75th meridian, standard time, corresponding to 11 a. m. of the 90th west of the Rocky Mountains they are sent out by the Observatory at the meridian, the standard time meridian of the Pacific Coast. The transmit shortly before noon, from the mean of three standard clocks that are ra signal is seldom in error to an amount greater than one or two tenths of a on long telegraph lines. Electric transmission over a continuous wire is noon, similar signals can be sent out by telegraph or telephone from the sa

(From the Annual Report of the Superintendent of the U. S. Naval

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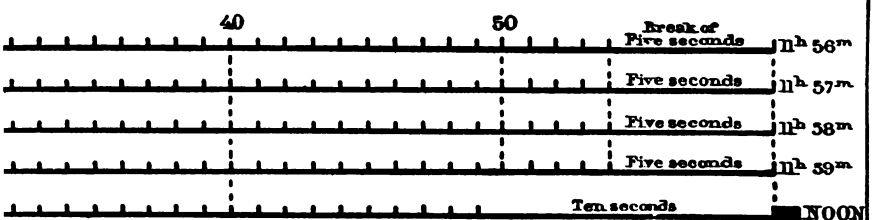
TIME SIGNALS

l Holidays, by the U. S. Naval Observatory.

hown graphically in the accompanying diagram. This represents the
/s a line upon a sheet of paper moving along at a uniform rate beneath
ick of the transmitting clock. The electric connections of the clock
ecord. These breaks enable anyone who is listening to a sounder in a
inute, especially the end of the last minute, when there is a longer
interval, or 10-second break, those who are in charge of time balls
il lines into circuit so that the noon signal drops the time balls and

continue for five minutes. During this interval every tick of the clock is transmitted
of the first four minutes, and finally the last ten seconds of the last minute. The



of the Rocky Mts., is noon of the 75th meridian west from Greenwich, corresponding
3. Navy Yd., for the Pacific Coast, it is 120th meridian time.

ll over the United States for an interval of five minutes immediately
gnals are sent out by the Observatory at Washington and end at noon
90th meridian and 10 a. m. of the 105th meridian. For the country
the Mare Island Navy Yard, California, and end at noon of the 120th
smitting clock that sends out the signals is corrected very accurately,
e rated by star sights with a meridian transit instrument. The noon
f a second, although a tenth more may be added by the relays in use
:e is practically instantaneous. For time signals at other times than
e same clock that sends out the noon signal.

aval Observatory for the Fiscal Year ending June 30, 1902.)

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REPORT

OF THE

SUPERINTENDENT OF THE NAVAL OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 28, 1902.

SIR: I have the honor to submit the annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1902.

DIVISION OF MERIDIAN OBSERVATIONS.

Upon the return of the officers composing the party to observe the eclipse of the sun in Sumatra, it became advisable to reorganize and systematize the work of the astronomical department. This was made necessary by the suspension of the office of astronomical director. The first step in this direction was to unite under one head all the meridian observations made at the Observatory and the instruments engaged therein, including the clocks, except the meantime clocks used in the time service. The senior professor of mathematics, Prof. A. N. Skinner, U. S. Navy, was put in charge of this division The division includes the 9-inch transit circle, the 6-inch transit circle, the clock vault, and the clock system used in meridian observations.

As noted in my last report, the 9-inch transit circle, through long years the only transit circle at the Observatory, has stood in need of extensive repairs; while the 6-inch transit circle, a new instrument, showed a serious defect in the form of a diurnal change in the constant of azimuth, following the changes of temperature. This defect made it inadvisable to dismount the 9-inch instrument for repairs until the defects of the 6-inch could be remedied. A systematic investigation to determine the cause of this defect had been carried on by Professor Updegraff, and several minor changes made in the mounting of the instrument had shown some improvement in the defect above noted. It was finally determined, however, to remove the marble piers on which the instrument rested, and to substitute piers built up of brick and Portland cement. This work was finished in October, and the result was highly satisfactory. The variation of azimuth has been reduced, and in fact almost eliminated, so that this really fine instrument is now available for the highest class of fundamental work. Some minor changes have still to be made, notably an adjustment of the azimuth mark, which is defective in distance. These additions and alterations will be made during the year. As soon as the success of Professor Updegraff's labors to correct the several defects of this instrument became assured the entire staff engaged in meridian observations was transferred to this instrument, and the 9-inch instrument

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was dismounted for repairs. For this purpose it was placed in the hands of Mr. G. N. Saegmüller of Washington, and progress has been made so that now within a few months the 9-inch will be remounted and will be as good as new. There are also some additions to be made to this instrument, but it is certain that when the 9-inch instrument will be remounted the Observatory will be in the possession of two first-class transit circles. These, together with the clock system, embracing a standard clock in an air-tight case, will put the Observatory in a position to do fundamental meridian work.

As some difficulty has been experienced in perfecting the old air-tight clock case, a new case is now under construction by Mr. G. N. Saegmüller, in which it is intended to mount the Howard clock. The Observatory is also considering a self-winding clock in an air-tight case. One difficulty in mounting a clock in an air-tight case is that provision has to be made for winding the clock on the outside of the case, and the hole and bushing which receive the key are pretty sure to leak air. Professor Skinner's report on the work and condition of his division is appended.

THE 26-INCH EQUATORIAL.

This instrument has remained during the year in charge of Prof. T. J. J. See, U. S. Navy, assisted by Mr. W. W. Dinwiddie and Mr. Gustave Harrison. Mr. Dinwiddie has been recently transferred from assistant on the great equatorial to assistant in spectroscopic work, and Mr. C. W. Frederick has been appointed to fill Mr. Dinwiddie's place as assistant. Professor See's report of the operations of this instrument is appended.

THE PRIME VERTICAL TRANSIT INSTRUMENT AND THE 5-INCH ALT-AZIMUTH.

These instruments have remained in charge of Assistant Astronomer George A. Hill, who has completed nine years of continuous observations of selected zenith stars for the purpose of obtaining corrections to the aberration and nutation constants, and also the variation of latitude. As this work is practically interminable, Mr. Hill will continue his labors with these two instruments.

The house which shelters the alt-azimuth instrument is a temporary building furnished by the contractor when the instrument was mounted. It is desirable to substitute a permanent building better adapted to the needs of the instrument. Besides this, an azimuth mark will be mounted under a suitable cover for the prime vertical transit instrument. The lens, cell, and bracket of this mark have been ordered, and the work of mounting them will proceed as soon as they are received from the hands of the makers. Attention is invited to Mr. Hill's report.

THE 12-INCH EQUATORIAL AND COMET SEEKERS.

These instruments are in charge of Assistant Astronomer Theo I. King. Besides the regular observations carried on with the 12-inch equatorial, this instrument is used for visitors. During the year 1,208 persons have visited the Observatory at night and were received by

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Mr. King. This number does not include those who have received special privileges or who have been accorded a view through the great equatorial. The 5-inch comet seeker has been used by Mr. George H. Peters since November, 1901. Mr. King's report is appended.

THE 40-FOOT PHOTOHELIOGRAPH.

This instrument is in charge of Mr. George H. Peters. Daily photographs of the sun are made whenever the weather permits. This instrument, which is of an old form, could well be replaced by a more modern one with a longer focus, giving a larger image. Mr. Peters's report is appended.

THE COMPUTING DIVISION.

This division was in temporary charge of Mr. King at the beginning of the year and is now in charge of Prof. W. S. Eichelberger, U. S. Navy, who resumed his duties at the Observatory on his return from the eclipse expedition to Sumatra. The object of this division is to assemble under one head all the work of revision and reduction of the observations made at the Observatory, thus reducing the work to a system. In addition to this work the head of this division is charged with the care of the archives and original records of the astronomical department, which have been gathered together from the various offices through which they were scattered, brought into one room, and indexed and arranged in suitable cases. In classifying these records and arranging them in the most convenient form for ready reference Professor Eichelberger has had the assistance of Assistant Astronomer King.

Besides the work of reduction of observations and the care of the records the computing division is also charged with proof reading. The labors of this division are important and arduous, and the number of computers is small in comparison to the amount of work to be done, especially in view of the earnest effort which is being made to bring the regular publications of the Observatory up to date. Double the number of computers could be well employed. I have been extremely conservative in my estimates, and have not asked for any excessive addition to the working force of the Observatory, but the time will come when such an increase must be made, because the Observatory is in a prosperous condition and its work is expanding and extending. It is highly desirable to bring the work up to date and to prepare observations for publication as soon as possible after they are made. In order to do this effectually there must be additions to this force from time to time, the present force being inadequate to the amount of work required of it and out of all proportion to the importance of the Observatory when taken in comparison with the force employed at other similar institutions. The labors of this division have also been hampered by the necessity of transferring from it computers to do the work which should be done and has always been done by naval officers, namely, the work of inspection of nautical instruments and as assistants in the department of chronometers and time service.

Since my last report, Volume II, Publications of the United States Naval Observatory, Second Series, has been published and 364 pages of Volume III and 52 pages of Volume IV have been put in type. Professor Eichelberger's report is appended.

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THE NAUTICAL ALMANAC OFFICE.

The report of the Director of the Nautical Almanac is hereto appended. The work of the office has been brought up to date, the Almanac for four years in advance being now in type. I ask particular attention to the recommendations of the Director of the Almanac regarding books of reference for the library and some increase in the salaries of the personnel. Scientific men in both the Observatory and the Nautical Almanac Office are underpaid, considering the very important work they do, requiring a knowledge of higher mathematics and familiarity with practical astronomy.

DEPARTMENTS OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

Commander Charles E. Fox, U. S. Navy, has remained in charge of these departments since my last report. During the year a total of 1,224 nautical instruments of all kinds has been received from the various sources, and 2,161 have been issued to the service. This does not include chronometers or watches, which are cared for by a separate department. All of these instruments have to be hauled by the Observatory wagons, and those which are issued to the service are packed in this building. I have repeatedly called the attention of the Bureau to the necessity of an increase in the force employed in these departments and also to the fact that it is highly detrimental to the service that the officer in charge of such important work should be detached without a relief. This has occurred more than once during my superintendency, and the result is to throw this important work into the hands of irresponsible and, in some cases, incompetent persons. The care, inspection, and selection of nautical instruments must be in the hands of a naval officer. A naval officer alone, or an experienced seaman, is competent to take charge of the requirements of the service in this respect. Moreover, the Bureau frequently refers to this office for inspection and report the various innovations and inventions submitted to it for consideration by outside parties. A seaman alone is competent to pass judgment in such cases. It is manifest that the Navy must have in its own hands the selection of the instruments which it uses in navigating its ships. To abandon this principle would be to throw open the service to innovators, inventors, and enthusiasts who are constantly introducing new forms of nautical instruments, for which they claim the greatest advantages and which they would substitute for the forms that have stood the test of time. The head of the department of nautical instruments should be a permanently established post at the Naval Observatory. I do not mean to say that it should always be held by one man, because any naval officer who has navigated a ship is fully competent to take up this work with very little preliminary training. This position might possibly be filled to advantage by a retired officer. Moreover, the two duties of general storekeeper and inspector of nautical instruments should be separated. Five years ago there were four line officers, besides the Superintendent, employed at the Observatory. The positions which these officers filled were, first, assistant to the Superintendent and general storekeeper; second, inspector of nautical instru-

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ments; third, head of department of chronometers and time service; fourth, assistant in the department of chronometers and time service. Since that time the work in these two departments has been vastly increased, owing to the addition of new ships to the Navy, while the number of officers employed has been reduced from 5 to 2, and sometimes only 1. The consequence is that it has been necessary to take the computers away from their legitimate duties in the computing division and to call upon them as assistants. I renew my repeated recommendation that these two departments should be put on a permanent and established basis with a sufficient force to carry on the work properly and to keep the books up to date. I have been obliged to place the bookkeeping in the hands of a clerk, to the detriment of the service in the Superintendent's office.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

Lieut. Commander E. E. Hayden has been in charge of this department since January 22, 1902. For the statistics of his work, the Bureau is referred to Mr. Hayden's report, which is appended. A change has been made in the method of sending out standard time at noon, by which the preliminary signal is sent five minutes before noon instead of three minutes, as formerly. This is found to be advantageous at distant stations. New methods have also been introduced to insure accuracy in time.

MAGNETISM AND METEOROLOGY.

As noted in my last report, magnetic observations have been discontinued. Meteorological observations are kept up under the same conditions as have been observed since the establishment of the Observatory.

GROUNDS AND ROADS.

Since my last report all the outlying tracts covered by the fund appropriated by the naval appropriation act of last year for the purchase of lands lying within the Observatory circle not included in the original purchase have been acquired by purchase, with the exception of the tract belonging to Mr. Philip Young and the tract belonging to the estate of Normanstone. The owners of these two tracts refused to accept the Government appraisal and appealed to the courts. A suit is now pending for the condemnation of these two tracts of land.

I renew my recommendation that a fence should be provided for in the next appropriation bill to completely inclose all the land belonging to the Observatory. I also renew my recommendation that no part of the present holding of the Observatory be sold under any consideration. I make this recommendation on the general principle that it is a mistake for the United States to part with real estate in the District of Columbia. The work of grading Massachusetts avenue is now in progress, and a satisfactory agreement has been reached with the Engineer Commissioner of the District whereby the grade adopted will not injuriously affect the Observatory grounds. The condition of the

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grounds and various buildings is good. The appropriation of $10,000 for the care of the grounds and extending the roads has been expended in laying out new concrete paths, grading, and continuing improvement of the hitherto unimproved portions of the grounds and the general care of the property. The appropriation of $5,000 allowed this year will be sufficient for the care of the grounds, but very little can be done in the way of grading. It would, however, be inadvisable to continue this work until that part of Massachusetts avenue which touches the Observatory circle shall have been completed. I recommend that when this is done the whole work of laying out the grounds be put into the hands of a competent landscape gardener. When Massachusetts avenue becomes a thoroughfare the Observatory grounds will form one of the most beautiful parks in the city of Washington, second only to the Soldiers' Home in extent and in picturesque beauty. The development of this place should be broadly planned and carried out so as to utilize to the utmost the great natural beauties of the grounds.

The report of the Secretary of the Navy for the fiscal year ending June 30, 1901, recommended to Congress the acquisition of the property of the Industrial Home School, as a part of this property lies within the Observatory circle. This would necessitate the removal of the school to a different site, and this removal will become necessary before long through the extension of population into this part of the city. The Superintendent of the Observatory was directed by the Department to place himself in communication with the secretary of the District board of charities and to seek to reach an agreement by which a proper compensation could be determined for this land. Acting in obedience to this order, I had several interviews with Mr. Wilson, the secretary of the board of charities; but I find that it will be impossible to reach an agreement on the basis of an appraisal of the actual money value, and I recommend that this question be referred to a board of appraisers. This would be the legal and regular course to pursue and would form an official basis for an estimate of the amount of money required for the acquisition of this property. The school is not in itself detrimental or objectionable to the Observatory; but at the same time it would be highly advantageous to own the land on which it stands.

LIBRARY.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1,1901	18,025	3,891	21,916
Accessions	353	84	437
Contents July 1, 1902	18,378	3,975	22,353

Of the accessions, 288 were received as exchanges and 149 were purchased.

During the year some improvements have been made by the addition of shelving and a partial rearrangement of the library. The librarian has also been engaged during the year in the perfection of a card catalogue.

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PERSONNEL.

The following changes have taken place in the personnel during the fiscal year:

Lieut. Commander E. E. Hayden reported for duty on January 22, 1902, and was assigned to the department of chronometers and time service.

Mr. F. B. Littell, assistant astronomer, resigned on September 25, 1901, and was appointed professor of mathematics, U. S. Navy, from September 20, 1901. Prof. F. B. Littell reported for duty September 27, 1901.

Mr. H. L. Rice was appointed assistant astronomer on April 15, 1902, to succeed Mr. F. B. Littell.

Mr. H. R. Morgan and Mr. C. W. Frederick, probationary piecework computers, received permanent appointments on September 27, 1901.

Miss Charlotte C. Barnum, a probationary piecework computer to October 6, 1901, resigned September 11, 1901.

Mr. E. I. Yowell was promoted from piecework computer to computer on permanent roll on July 30, 1901, and Mr. H. R. Morgan also from piecework computer to computer on permanent roll on December 24, 1901.

John Brockman was temporarily appointed a laborer July 22, 1901, and permanently appointed on January 23, 1902.

V. Muehlhaus, jr., was appointed a watchman on February 7, 1902, to succeed J. C. Bronaugh, who died January 30, 1902.

THE BOARD OF VISITORS.

As noted in my last year's report, the Board of Visitors, established by the naval appropriation act approved March 3, 1901, met in April of that year, and prior to July 1 two duly constituted committees of the board visited the Observatory officially. This completed the total number of visits allowed by law during any one year. Notwithstanding this fact, the board met again in October, 1901. The report of the board is based upon these four meetings. As the report is another attack on the organization of the Observatory, it is proper that I should briefly review it, although any extended criticism of the report or an answer to the arguments adduced by the board in favor of a change of organization is of course out of the question in the limits of this report. The board was constituted by the same act of Congress which confirmed the naval superintendency, an office which has been permanent at the Observatory ever since its foundation as a naval establishment, sixty years ago. The law was observed in perfect good faith both by the Chief of the Bureau of Equipment and by the Superintendent, who justly regarded the board as a legally constituted branch of the organization of the Observatory, and received the board accordingly. The board on the other hand, while seeking to strengthen its own position, has made a gratuitous attack on a part of the organization which is coordinate with itself by law. In doing this the board puts itself into the position of impugning the law by virtue of which it itself exists. The report of the Board of Visitors this year is in some ways a repetition of the report of the board of 1899; that is to say, the whole report

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is colored by the determination of the board to overthrow, if possible, the naval administration of the Observatory, only in the present instance the board is a legally constituted body and its functions, powers, and duties are distinctly defined by law.

The board is required to report on the efficiency with which the scientific work of the Observatory is prosecuted. This the board failed to do. The board is also required to report as respects the expenditures in the administration of the Observatory. This the board evaded with the remark that "from the manner in which the appropriations have been made it is not easy for the Board of Visitors to determine what portions of the expenditures pertain properly to astronomical work, what portion to naval work, and what portion to the improvement and care of the grounds as a park." It would have been easy for the board to determine these questions had it taken the trouble to look into the matter. The wording of the various clauses of laws making appropriations for the Observatory is perfectly clear and can not be misunderstood. The appropriations are apportioned under various headings and subheadings, and it is not discretionary, of course, with the Superintendent to divert the funds from one appropriation to another, or to spend any money for purposes for which the law does not appropriate it. In fact, it would be impossible for him to do so, and yet this is clearly the imputation of the board's language.

Another requirement of the board, "that it shall prepare and submit to the Secretary of the Navy regulations prescribing the scope of the astronomical and other researches of the Observatory and the duties of its staff with reference thereto," is really the most important function of the board, but the board dismisses it with a few vague recommendations which show that the board took no pains whatever to inquire as to the status of the work of the Observatory or as to the policy of the Observatory in past years. As an example of the value of the board's recommendations it may be noted that the board, on page 6 of its report, says:

> As examples of special researches that might have been taken up under such a system may be mentioned the comparison stars for Victoria and Sappho proposed by Dr. Gill in 1889, and the comparison stars selected by the Astrophotographic Conference of 1900 for observations of Eros.

This leaves the clear imputation that this work has not been done at the Observatory. In point of fact, not only have all these observations been made, but those of the comparison stars for Victoria were actually made in part by a member of the Board of Visitors, then an assistant at the Naval Observatory. His signature occurs in the original record books of this work. The Observatory holds the official receipt of Dr. Gill, and Dr. Gill himself publicly acknowledges this member's share of the work. (A Determination of the Solar Parallax and the Mass of the Moon, by David Gill, LL. D., etc. Annals of Cape Observatory, Vol. VII, p. 559.) This single example is a vivid illustration of the attitude of the Board of Visitors toward the Observatory. Nor is this the only instance of the board's ignoring work actually performed, with a similar imputation.

There is one more feature of the report of the Board of Visitors to which I desire to call the particular attention of the Bureau. Both the board of 1899 and the present Board of Visitors wholly ignored the strictly naval part of the Observatory's functions. They take no note whatever of the purchase, inspection, and distribution of nautical,

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astronomical, and surveying instruments for the use of the Navy; of the purchase, test, and issue of chronometers; and they dismiss the important question of the time service with a recommendation which is impracticable. The board seems to seek to convey the impression that a great deal of money is spent at the Observatory for very inadequate results, and yet in point of fact the astronomical expenses of the Observatory bear an insignificant ratio to the money value of the transactions in the departments of nautical instruments and chronometers. From a financial standpoint these two departments are far more important than the whole of the astronomical work combined.

The Board of Visitors assumes to represent the opinion of the astronomers of the country. It may be conceded that astronomers as such might have a right to be heard as to the affairs of the Government Observatory. Not only that, the Observatory would encourage such a claim. But in order to advance it the attitude should be one of sympathy and encouragement. A movement on the part of the astronomers to promote scientific efficiency would be met more than half way; but to hamper the Superintendent in the execution of the duties of a purely administrative office and in his efforts to maintain order, system, and discipline (without which no human institution can succeed), to promote discontent and discord within, to stir up animosity without, to suppress facts, evade duties imposed by law, impugn the law itself, so color an official report that nothing creditable shall appear even to the extent of direct imputations contrary to known fact, calculated to excite prejudice and convey a false impression, and, finally, to seek to promote discord and inefficiency in order to prove that they exist—such an attitude is an abrogation of any claim to interest which might otherwise exist. Under the circumstances the refusal of Congress to provide for the expenses of the board during the fiscal year 1902–3 can not be considered a loss to the growing efficiency of the Observatory.

I am, sir, your obedient servant,

C. H. DAVIS,
Captain, U. S. Navy,
Superintendent of the Naval Observatory.

The CHIEF OF THE BUREAU OF EQUIPMENT,
Navy Department.

THE DIVISION OF MERIDIAN OBSERVATIONS.

SIR: The work on the 9-inch transit circle from July 1 to 30, 1901, was in charge of Assistant Astronomer Theo I. King. For convenience of reference the observations taken during this period are included in the schedule of the sun, moon, and planet observations.

The division of meridian observations, including the 9-inch transit circle, the 6-inch transit circle, and the clock vault, was organized by the Superintendent July 30, 1901.

ASTRONOMISCHE GESELLSCHAFT ZONE, -13° 50′ to -18° 10′.

[In charge of Prof. A. N. Skinner, U. S. Navy.]

The few observations necessary to complete the Astronomische Gesellschaft Zone have been made by me. The journal of these zone

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observations, with the star positions reduced to 1900, has been printed during the year and was ready for distribution July 1, 1902. This work constitutes Volume II, Publications of the United States Naval Observatory, Second Series.

The work remaining to be done on this zone is the collation of the catalogue, the discussions therein involved, and the comparison of the results with other authorities. During the past year I have devoted a part of my time to this work, as the computing force has been wholly occupied in proof reading and other urgent work.

The number of observations made during the year is as follows:

Zone stars	32
Zero stars	23
Total	55

SUN, MOON, AND PLANET WORK.

[In charge of Prof. F. B. Littell, U. S. Navy.]

The sun, moon, and planet work was continued on the 9-inch transit circle until October 24, 1901, when this instrument was put out of use for repairs. On October 25, 1901, this work was transferred to the 6-inch transit circle.

The plan has been to have the work carried on at any one time by three observers. The following have been employed as observers at various times during the year: Prof. A. N. Skinner, U. S. Navy; Prof. F. B. Littell, U. S. Navy; Assistant Astronomer H. L. Rice, Computer E. A. Boeger, Computer W. M. Brown, Computer E. I. Yowell.

The number of observations from July 1, 1901, to June 30, 1902, is as follows:

Ephemeris stars	1,933
Sun	144
Moon	150
Mercury	74
Venus	121
Jupiter	13
Saturn	11
Uranus	9
Neptune	11
Miscellaneous stars	19
Thread interval stars	24
Total	2,509

STAR WORK.

[In charge of Prof. Milton Updegraff, U. S. Navy.]

The transfer of the sun, moon, and planet work to the 6-inch transit circle necessarily confined the general star work to the intervals when the instrument was not in use by Professor Littell and his assistants.

The subjects of observation during the year were the following:

From October 18 to 23, 1901, 194 observations of stars from Gill's Catalogue of 2,798 Zodiacal Stars.

Beginning with November, observations on Newcomb's Catalogue of Fundamental Stars.

From February 6, observations of certain comparison stars selected by Gill for heliometer observations of the planets.

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The number of observations of stars made is 3,588, of which 2,837 were made by Professor Updegraff, assisted by Mr. J. C. Hammond, computer, and 751 by Mr. Hammond, assisted by Mr. C. W. Frederick, miscellaneous computer.

Observations of stars.

Clock stars	480
Stars of Newcomb's Fundamental Catalogue	1,840
Zodiacal stars	558
Circumpolar stars	161
Screen stars for personal equation	165
Stars observed for personal equation due to position of observer	169
Stars observed for various purposes	215
Total	3,588

Determinations of instrumental constants.

Azimuth of meridian mark	201
Azimuth of instrument from mark	539
Level (by spirit level)	368
Level (by observations over mercury)	126
Collimation	229
Nadir point, Circle A	248
Nadir point, Circle B	253
Runs of microscopes	120
Total	2,084

CONDITION OF THE APPARATUS.

The 9-inch transit circle.—Certain very material changes, repairs, and improvements were found necessary on this instrument. Among the more important were the following:

The introduction of central field illumination.

New journals for the counterpoise rollers.

Knife-edge fulcrums for the counterpoise levers.

New pivots.

A new telescope micrometer.

These repairs were entered upon by Mr. G. N. Saegmüller on November 29, 1901, and are now in progress.

The 6-inch transit circle.—This instrument, which had been dismounted to receive certain changes and improvements under the superintendence of Professor Updegraff, who had made a special study of it, was remounted on the new brick piers in October, 1901.

As a result of the changes which have been effected, the constants of this instrument have been stable to a satisfactory degree.

The circles, which were regraduated during August and September by Messrs. Warner & Swasey, were received on September 30, 1901. The sharpness and regularity in form of the divisions have been greatly improved.

The amount that the north meridian mark is out of focus has been measured at various temperatures, ranging from +18° to +84° F., and has been found to be about 4½ feet at all temperatures.

The correction of this error in the position of this mark, together with the completion of the work of fitting the auxiliary microscopes for use in the determination of division errors, has been deferred by the Superintendent until after the remounting of the 9-inch transit circle.

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CLOCK VAULT.

[In charge of Prof. Milton Updegraff, U. S. Navy.]

The sidereal clock Howard No. 404 was mounted in the clock vault on October 16, 1901.

The average deviation of the daily rates from the mean rate for periods of three or four weeks has been about $0^s.03$, while formerly, when mounted in the clock room and subject to great changes of temperature, the deviation of the daily rates was about six times as large. The temperature coefficient of this clock was determined during January and February, 1902, and found to be about $0^s.06$ per degree Fahrenheit. At the end of the year this clock showed evidence of need of cleaning and oiling.

The Kessel's clock mounted in a copper case also shows a need of cleaning and oiling.

An air-tight case made for the Howard clock No. 404 by Mr. G. N. Saegmüller, of Washington, has been delivered at the Observatory, but has not yet been brought into use.

The thermostat, with electrical connections for controlling the gas stove which warms the clock vault, needs some improvement to secure a constant temperature in the vault.

REMARKS ON THE REPORT OF THE BOARD OF VISITORS.

Near the bottom of page 5 of the Report of the Board of Visitors for 1901 is given a provisional plan for meridian work. This plan is not accompanied by any statement concerning the existing work of the Observatory. To avoid a natural misapprehension owing to the absence of such a statement, attention is called to Volume I, Publications of the United States Naval Observatory, Second Series, Transit Circle Observations of the Sun, Moon, Planets, and Miscellaneous Stars, 1894–1899, 423 pages, quarto. Attention is also called to the fact that the current meridian work of the Observatory substantially cares for everything in the plan above noted in the Board of Visitors' report.

In the same connection I quote the following paragraph:

> As examples of special researches that might have been taken up under such a system may be mentioned the comparison stars for Victoria and Sappho proposed by Dr. Gill in 1889 and the comparison stars selected by the Astrophotographic Conference of 1900 for observations of Eros.

A reference to our published volumes shows that Gill's Victoria and Sappho stars of 1889 were observed during that year at the Naval Observatory. Also a very slight investigation of the current work of the Observatory would have informed the Board of Visitors that Eros and its comparison stars had received very complete attention by numerous observations on three instruments of the Observatory. These observations fill over 200 pages of Volume III, Publications of the United States Naval Observatory, Second Series, now in press.

Respectfully submitted,

A. N. SKINNER,
Professor of Mathematics, U. S. Navy,
In charge of Division.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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THE 26-INCH EQUATORIAL.

SIR: I have the honor to submit the following report on the work of the 26-inch equatorial:

During the year which has just closed this instrument has been devoted to the same general lines of work as in former years. Continuity in the observations of the satellites of Saturn and Uranus is thus preserved, and some distinctly new lines of work have been added in the measurement of diameters of the planets and satellites by daylight, intended primarily for eliminating the effects of irradiation. A thorough investigation of the micrometer screw has also been carried out and a temperature coefficient established which will make possible the most refined measurements, as in researches on the orbits of the satellites and masses of the planets and on the parallax of the fixed stars.

I. STATE OF THE INSTRUMENT.

The satisfactory condition of the instrument noted in the last annual report has been still further improved by the addition of a set of contact rings for conveying the electric currents from the pier to the eye end of the telescope. These were designed by Mr. W. Walter Dinwiddie and constructed by Mr. M. E. Kahler, of Washington. Each ring has five conductors, making it possible to have four independent circuits. The ring about the polar axis is attached to the right ascension clamp ring and turns with the axis, while its brush is fastened to the case of the worm screw. The other ring is fastened to the declination sleeve and its brush to the declination clamp ring. The brushes have five conductors separately insulated to correspond to the number of conductors on the rings. Each conductor of the brush has four contact pins, and each pin is pressed against the ring by a separate spring, making it impossible for a particle of dust on the ring to interrupt the circuit. This part of the device is a marked improvement on the flat springs heretofore used. In addition to the labor of putting them on, which was done at the Observatory, the cost of the rings and brushes for this instrument was only about $70, an expense so inconsiderable that the device may be recommended for large equatorials generally. The Leander McCormick Observatory of the University of Virginia has recently been equipped with this apparatus from designs supplied by Mr. Dinwiddie. A 6-inch Dallmeyer portrait lens of 40 inches focal length has been mounted on the middle of the telescope tube opposite the declination axis. The camera is adapted for 4 by 5 plates and may be found useful in asteroid and comet work. With this form of mounting no flexure can be detected, even in the longest exposures. The elevating floor continues to perform well, and all the delicate machinery of the instrument is in excellent condition.

II. VALUE OF A REVOLUTION OF THE MICROMETER SCREW.

The observations of Eros for the solar parallax made in 1900–1901 necessitated a very thorough investigation of the value of the micrometer screw. On several accounts this could not be finished during the period immediately following the opposition of Eros, and accordingly the scope of the investigation has been greatly extended and

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the work completed during the past year. With a view of finding the coefficient depending on seasonal changes in temperature, twelve long arcs in the Pleiades and two in Perseus were chosen for measurement during the summer and winter, respectively, and the observations carried out under as uniform conditions as practicable, with a large difference in the average temperatures of the two seasons. A detailed statement of these results will be given in the observations of Eros, soon to appear in Part I of Volume III, Publications of the United States Naval Observatory, Second Series, but for the present report the general character of the investigation may be sufficiently inferred from the following summary:

Arc.	In summer.			In winter.		
	Value of one revolution.	Number of measurements.	Weight.	Value of one revolution.	Number of measurements.	Weight.
	″			″		
AZ Persei	9.9291	6	12	9.9348	3	13
kl Persei	9.9294	4	8	9.9340	3	12
Celaeno–Electra	9.9286	4	6	9.9277	6	9
18*m*–Taygeta	9.9317	4	9	9.9308	6	13
Bessel 3–Bessel 5	9.9260	4	10	9.9322	4	12
Maia–Asterope *k*	9.9295	4	6	9.9308	6	9
Bessel 9–Merope	9.9278	3	5	9.9309	6	10
Bessel 17–Bessel 18	9.9318	4	9	9.9327	5	11
24*p*–Bessel 20	9.9313	4	9	9.9317	5	12
Bessel 24–Alcyone	9.9293	4	6	9.9288	6	9
Bessel 21–Bessel 25	9.9299	3	10	9.9332	6	21
Atlas–Pleione	9.9367	4	4	9.9363	8	8
Bessel 30–Bessel 31	9.9326	4	10	9.9340	4	15
Bessel 37–Bessel 38	9.9333	4	10	9.9380	4	15
	9″.9304±0″.00036			9″.9328±0″.00028		

The mean temperature for the summer work was 72°.5 F., while at the winter season it fell to 28°.6 F. The weights are proportional to the square roots of the lengths of the arcs, multiplied by the number of independent measurements. The difference in the value of the screw between winter and summer is +0″.0024. This corresponds to a change of temperature of 44° F. Our general formula for the value of a revolution of the micrometer screw is therefore—

R=9″.9304+(0″.000055) (72°−T.) (for summer work); or

R=9″.9328−(0″.000055) (T−28°) (for winter work).

The mean focal length of the object glass is 389.66±0.05 inch (Wash. Obs., 1877, App. I, p. 11). Under the variations of temperature, depending upon the seasons, this focal length has been found to change relative to that of the steel tube, lengthening in summer and shortening in winter, the amount of the alteration being 0.095±0.012 inch. This is 1:4101 of the total focal length, and from this cause the revolution of the screw would change by 0″.0024±0″.0003. Accordingly we reach the remarkable result that the change in the value of the screw deduced from the measurement of the fixed stars in summer and in winter, respectively, is due wholly to change of focal length of the objective relative to the tube. It appears that the coefficient of expansion of the tube and of the screw are practically identical, so that the proportions of the triangle formed by any two points on the axis of the screw and the center of the object glass are constant throughout the year, and no change in the value of a revolution occurs except for the change in the adjustment of focus. It should be stated that the

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two ends of the tube are made of sheet steel, joined to a central section of gun metal, 36.25 inches in length. As thus constituted the tube as a whole and the screw have sensibly the same coefficients of expansion. Mr. C. W. Frederick, formerly miscellaneous computer, now assistant on the great equatorial, has rendered important assistance in the reduction of the measurements discussed above.

III. MEASUREMENT OF THE DIAMETERS OF THE PLANETS AND SATELLITES.

The series of measures of the diameters of the planets and satellites noted in the last annual report has been continued, and the usual observations by night have been supplemented by an extensive series of measures by daylight designed to afford the means of eliminating the effects of irradiation. It is well known that this cause renders the apparent diameters of the planets as seen in the telescope at night sensibly larger than their natural size, and yet no entirely satisfactory method for eliminating the irradiation has ever come into use among astronomers. The method developed here last year is a purely empirical one, depending on the difference between the diameter found by night when the planet is enlarged by irradiation and that found by daylight, when the pale disk is projected against a bright sky. As seen under suitable illumination by daylight the disk of a planet appears faint but perfectly definite, and when the seeing is quiescent and the light of just the right intensity the limb is singularly sharp, so that the most precise measures may be made. The best time of day for taking these observations is just before the setting of the sun, when the atmospheric currents have ceased to ascend from the heat of the day and have not yet begun to descend from the cooling effect which follows the advance of night. In the work on Mercury and Venus good seeing was sometimes had in the forenoon and also in the afternoon. About sunrise is also an available time for measuring by daylight, but the seeing of the early morning is usually inferior to that at sunset on account of the currents which usually trouble the atmosphere when it is first illuminated by the rays of the rising sun.

Jupiter.—A series of measures of the equatorial diameter of this planet taken just before the setting of the sun gives a mean value of $37''.646 \pm 0''.014$. The uncertainty attaching to this value is probably about one one-thousandth of the whole. The diameter of Jupiter deduced here during the opposition of 1900 from measurements taken at night was $38''.401$. This diameter accords very closely with those of other standard observers, and may be accepted as giving the dimensions of the planet when enlarged by irradiation. The difference of $0''.755 \pm 0''.040$ is the irradiation constant, and is so considerable a quantity that it can not be neglected in future observations of the diameters of the planets.

Saturn.—During the past autumn a series of 82 measures of the equatorial diameter of Saturn was secured just before sunset, leading to a mean value of $17''.240 \pm 0''.006$. As Saturn is considerably fainter than Jupiter, the micrometer settings had to be timed by the observer's judgment as to the moment when the illumination of the sky had attained the proper intensity. By a little experience it was found that this could be done with perfect success. It is difficult to understand how the resulting mean diameter can remain uncertain by more

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than 0″.02, or 1:862 part of the whole. A parallel series of 28 sets of diameters was also taken by night under conditions of perfect seeing, the mean yielding a value of 17″.804±0″.011. These independent results indicate that the irradiation constant for Saturn is 0″.56. Some observations were also taken on the rings by daylight with a view of finding their constants of irradiation. The outcome of these measures is indicated in the following table:

	Asobserved at night.	As corrected for irradiation.
	″	″
External diameter of the outer ring	40.274	39.971
Internal diameter of the outer ring, or external diameter of Cassini's division	34.757	34.605
Diameter of the center of Encke's division	37.747	37.747
Width of Encke's division	0.107	0.410
Total width of the outer ring	2.758	2.455
Width of the outer part of the outer ring	1.237	0.934
Width of the inner part of the outer ring	1.414	1.111
Width of Cassini's division	0.418	0.818
External diameter of central ring	33.921	33.671
Internal diameter of central ring, or external diameter of dusky ring	25.932	25.932
Width of central ring	3.995	3.745
Internal diameter of dusky ring	20.434	20.434
Width of dusky ring	2.749	2.749
Black space between Saturn's globe and dusky ring	1.315	1.597
Equatorial diameter of Saturn	17.804	17.240
Assumed oblateness of Saturn (H. Struve's value)	0.1013	.....
Polar diameter with this oblateness	16.005	15.494
Assumed mass of Saturn (H. Struve's value)	1:3495.3	.....
Resulting mean density of the planet	.....	0.7105

Uranus.—A series of 30 measures of the diameter of Uranus made under favorable conditions during the opposition of 1901 led to a diameter of 3″.46. A series of 13 diameter measures of the planet by daylight, taken immediately after the setting of the sun, when the illumination of the sky had the requisite intensity for counteracting the irradiation without encroaching upon the disk, gave a value of 3″.07. The resulting constant of irradiation of Uranus is 0″.39. Using a diameter of 3″.07 the resulting specific gravity of Uranus is 2.09, nearly twice that given in many standard works on astronomy.

According to observations made here last year the irradiation constant for Mars (0″.76) was then almost exactly the same as that of Jupiter (0″.75). As the orbit of Mars is quite eccentric this constant will vary from about 0″.70, when Mars is in aphelion, to 1″.02, when in perihelion. It is therefore not to be expected that observers of the planet at different epochs who take no account of irradiation would obtain consistent values of the diameter. It is well known that on the average the limb of Mars is somewhat brighter than that of Jupiter. The mean value of its irradiation is 0″.86, which agrees well with that of Jupiter (0″.75). It may also be observed that the values deduced for the planets Saturn (0″.56) and Uranus (0″.39) accord well with their respective brightnesses. So far as I am aware, the law of the variation of irradiation with brightness has never been accurately determined. Probably for changes which are not too great, a law of strict proportionality to brightness may be assumed. Proceeding upon this hypothesis I have adopted the following preliminary table of diameters of the planets of the solar system. Their resulting densities are also added for convenience of reference:

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Planet.	I. Diameter by night.		II. Diameter by daylight.		Irradiation.		(II. Diameter) Density.
	"	*Miles.*	"	*Miles.*	"	*Miles.*	
Mercury	6.20	2,893	5.90	2,658	0.30	135	3.00
Venus	17.16	7,732	16.80	7,570	0.36[a]	162	5.14
					0.72	334	
Earth	17.592	7,917.6	.....	.....	.....	.....	5.50
Mars	9.68	4,572	9.30	4,190	0.38[a]	191	4.00
					0.76	382	
Jupiter	38.40	88,079	37.65	86,310	0.75	1,769	1.35
Saturn	17.80	74,019	17.24	71,595	0.56	2,424	0.71
Uranus	3.46	29,949	3.07	26,578	0.39	3,371	2.09
Neptune	2.20	29,909	2.00	27,190	0.20	2,719	2.29

[a] The irradiation seen in the telescope is the larger value; reduction to distance unity about halv es the angle subtended.

During the past year further measures were made on the diameters of Jupiter's satellites, and of Titan, the principal satellite of Saturn. The principal results were:

Satellite.	I. Diameter by night.		II. Diameter by daylight.		Irradiation.	
	"	*Miles.*	"	*Miles.*	"	*Miles.*
Jupiter I	1.08	2,523	0.83	1,954	0.25	569
Jupiter II	0.98	2,287	0.75	1,750	0.23	537
Jupiter III	1.60	3,758	1.26	2,964	0.34	794
Jupiter IV	1.44	3,376	1.17	2,739	0.27	637
Titan	0.87	3,736	0.73	3,137	0.14	599

Using the masses of these satellites adopted by the late Prof. J. C. Adams, the resulting densities are:

Mass according to Adams.	Satellite's mass in units of earth's.	Density.	Satellite.
0.0000283113	1:111.2	3.29	I
0.0000232355	1:135.5	3.76	II
0.0000812453	1: 38.75	2.71	III
0.0000214880	1:146.5	0.90	IV

If the simple mean of these numbers be taken, we shall find a specific gravity of 2.49, which is about the same as that of the matter composing the crust of the earth. But if the satellites be given weight proportional to their volumes, the resulting average specific gravity of all the matter composing the four satellites is 1.78, in almost exact accord with the density of Titan, which with a mass of 1:4700, as found by Hill and H. Struve, comes out 1.79. This close agreement is of course accidental, yet I think the probability is considerable that the densities now found for these satellites do not depart widely from the truth.

Mercury.—A series of 38 determinations of the diameter of this difficult planet taken May 30, June 1, and June 3, 1902, when the apparent diameter ranged from 8″ to 9″, give a mean value of 6″.160 at distance unity. During these measures the cusps were sharper than in the long series of measures taken last year, and of course the apparent diameter was also larger; yet the observations confirm those of last year in indicating that the diameter of Mercury is smaller than

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heretofore supposed. Some further work on this difficult planet is in contemplation, but it must be deferred until the conditions are quite favorable, in order to be of decided value.

IV. OBSERVATIONS OF THE SATELLITES.

The series of observations of the satellites noted in the last annual report has been extended, and the programme of work arranged so as to include all the satellites of Saturn and Uranus.

Satellites of Saturn.—A long series of measures of these objects taken in pairs by Prof. Hermann Struve's methods has been secured.

During the opposition of 1901—

Iapetus—Titan were measured on 55 nights.
Hyperion—Titan were measured on 33 nights.
Titan–Rhea were measured on 66 nights.
Dione–Tethys were measured on 64 nights.
Tethys–Enceladus were measured on 52 nights.

Observations were resumed April 30, 1902, and up to June 30 the following observations had been secured:

Iapetus–Titan on 20 nights.
Hyperion–Titan on 10 nights.
Titan–Rhea on 23 nights.
Dione–Tethys on 23 nights.
Tethys–Enceladus on 16 nights.
Tethys–Mimas on 6 nights.

Thus the total number of measures during the fiscal year were—

Iapetus–Titan on 53 nights.
Hyperion–Titan on 32 nights.
Titan–Rhea on 61 nights.
Dione–Tethys on 61 nights.
Tethys–Enceladus on 49 nights.
Tethys–Mimas on 6 nights.

With the exception of Mimas and Hyperion, these satellites are comparatively easy objects. Hyperion is always difficult, except when the sky is very clear and the moon is dark, and it is generally advisable to put the planet out of the field when making the measures. Mimas is so faint, as seen in the mass of light which surround the rings, that it comes out clearly only when the seeing is quite steady. The importance of making a good series of measures of this tiny object with a view of redetermining the oblateness of Saturn from the motion of the perisaturnium of Mimas justifies the attention which has been paid to it during the present opposition, but up to June 30 the weather has been so unfavorable that only a few measures have been secured. It may, however, be expected that the middle and latter half of the opposion will yield ample results for the determination of the elements, as the observer's experience in recognizing this difficult object will now enable him to utilize every good night to advantage in obtaining several sets of measures while the satellite is passing elongation.

Satellites of Uranus.—These objects were measured regularly on all available clear nights. It was found that the two inner satellites, Ariel and Umbriel, although within the grasp of the telescope, were

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yet so faint that they can not be advantageously observed in the present position of the planet. During the opposition of 1901 the following measures were obtained:

Oberon on 41 nights.
Titania on 41 nights.
Oberon–Titania on 41 nights.
Umbriel on 15 nights.
Ariel on 18 nights.

Up to June 30, 1902, the following observations have been secured:

Oberon on 21 nights.
Titania on 25 nights.
Oberon–Titania on 21 nights.

During the fiscal year 1901–2 the following observations were made:

Oberon on 39 nights.
Titania on 39 nights.
Oberon–Titania on 39 nights.
Umbriel on 8 nights.
Ariel on 11 nights.

V. MISCELLANEOUS OBSERVATIONS.

During the past year only a limited number of double stars have been observed; in all about 107 observations of pairs, selected mostly from the lists of Burnham and Struve. Measures were also made of the faint companions of Sirius and Procyon. With the increase of force now attached to the instrument the hope is entertained of extending the double-star work considerably during the coming year. Three observations have been made of the asteroid Minerva (93) and two of Chicago (334). The observations of the latter were made by Mr. Dinwiddie; those of the former by Mr. Dinwiddie and Mr. H. R. Morgan, computer. Two observations of Encke's comet were also secured; one by myself, the other by Mr. Dinwiddie.

VI. PUBLICATIONS.

During the year 1901–2, the following publications relating to the work of the great equatorial have been issued:

1. Researches on the Diameter of Mercury. (Astronomische Nachrichten, No. 3737.)
2. On the Probable Mass and Density of Mercury, and on the General Principles Governing the Densities of the Four Inner Planets. (Astronomische Nachrichten, No. 3743.)
3. Preliminary Investigation of the Diameter of Mars (observations by daylight). (Astronomische Nachrichten, No. 3750.)
4. Researches on the Diameter of Jupiter (observations by daylight). (Astronomische Nachrichten, No. 3757.)
5. Observations of the Diameters of the Satellites of Jupiter and of Titan, the principal satellite of Saturn (observations by daylight). (Astronomische Nachrichten, No. 3764.)
6. Micrometrical Measures of the Equatorial Diameter of Saturn and of his system of rings (observations by daylight). (Astronomische Nachrichten, No. 3768.)

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7. Micrometrical Measures of the Diameter of Uranus (observations by daylight). (Astronomische Nachrichten, No. 3768.)

8. Observations of (26) Proserpina, by George K. Lawton. (Astronomische Nachrichten, No. 3786.)

9. A device for conducting electric circuits to the eye end of an equatorial telescope, by W. Walter Dinwiddie. (Popular Astronomy, June, 1902.)

The measures of the satellites during the opposition of 1901 have been properly reduced and communicated to the Astronomische Nachrichten for publication.

The observations of Eros for the parallax of the sun made during the opposition of 1900-1901, designed for Part I of Volume III, Publications of the United States Naval Observatory, Second Series, is in type and will probably be issued before the end of the present calendar year.

VII. PERSONNEL.

The personnel of the instrument during the past year has been as follows:

T. J. J. See, professor of mathematics, U. S. Navy, astronomer in charge.

W. Walter Dinwiddie, assistant on the great equatorial.

Gustave Harrison, laborer.

I would fail in a plain duty if I did not commend the meritorious services of Mr. Harrison to the Superintendent's consideration. Among the Observatory employees I know of none more deserving of promotion, and accordingly an appropriate advancement for him is strongly recommended.

On July 1, 1902, Mr. Dinwiddie was transferred, by examination held through the Civil Service Commission, to be assistant in spectroscopic work, and Mr. C. W. Frederick, miscellaneous computer, appointed assistant on the great equatorial. This rearrangement will give Mr. Dinwiddie somewhat greater facility for studying certain physical problems, and it has also the important effect of supplying an adequate working force to the instrument for the first time in its history.

It is hoped that during the coming year this enlarged observing force will permit of more extensive measurement of double stars, besides some astrophysical work which may be advantageously undertaken. I also contemplate entering upon some researches on stellar parallax, but it is not probable that these new investigations can be begun during the coming year on account of the attention which for the present should continue to be given to the satellites of Saturn and Uranus.

In concluding this report, it does not seem inappropriate to invite the attention of the Superintendent to the important results achieved with this instrument during the past three years. It is noticeable, however, that the report of the Board of Visitors for the year 1901 made no mention of any work with the great equatorial. Will any one believe that this omission was accidental, or that it was actuated by a sincere desire to do justice to the scientific status of the Observatory?

The law specifically required a detailed report upon the activity of every instrument, and as perfect silence is maintained regarding the

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activity of the equatorial, the aforesaid report, if believed, might make the impression upon the Secretary of the Navy, or upon the President and Congress, that the equatorial is practically idle. Fortunately, the proceedings of the board were so clearly illegal, and their aims so transparent, that the report commanded no confidence among intelligent persons, either in public or in private life.

Respectfully,

T. J. J. See,
Professor of Mathematics, U. S. Navy,
In charge 26-inch Equatorial.

The Superintendent of the Naval Observatory.

THE PRIME VERTICAL TRANSIT AND THE 5-INCH ALT-AZIMUTH.

Sir: For the year ending June 30, 1902, the following is respectfully submitted as the report upon the astronomical observations made and the condition of the instruments in my department.

During the year I made with the two instruments 964 determinations of the places of stars.

PRIME VERTICAL TRANSIT.

On the 28th of July, 1902, I will have completed with the prime vertical transit nine years of continuous observations of selected zenith stars for the purpose of obtaining corrections to the aberration and the nutation constants, and also the variation of latitude.

From the commencement of the series the stars of which positions have been observed are relatively bright, since the problem demands observations by day as well as by night. As it has been shown that a personal equation, depending upon magnitude, exists in all transit observations made in the meridian, I have thought it desirable to determine my personal equation with an instrument used out of the meridian.

In his discussion of the places of the comparison stars for Victoria in 1889, Dr. Auwers assigns, in the case of transits observed in the meridian at this Observatory, a personal equation of $-0^s.023$ (M–8.0), in which M is the magnitude of the star observed.

I have not thought it expedient to use a screen before the object glass in observing the bright stars, from the liability of introducing systematic errors into the derived declinations.

To prepare a method by which my personal equation might be obtained, I selected from the Potsdam and Harvard photometric catalogues all stars situated between declinations $+37^\circ$ and $+37^\circ$ 55′, and from the brighest down to the 7.9 magnitude. The latter is about the limit for observations with a bright field illumination for a glass of the size of the prime vertical transit.

There are about 392 stars in the list selected. The plan is to secure five observations of each star. At this date, of the 2,000 observations to be made, about 85 per cent are finished. The whole series will be completed some time next December. The largest gaps are within the region from 4 hours to 9 hours, R. A., and these were caused by the continued cloudy weather in the early spring.

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Assuming that the level of the instrument is zero, and that the instrument is in the prime vertical, the declination is determined by the formula, $\tan \delta = \tan \varphi \cos h$. Or, if the latitude is desired, it may be found from the formula $\tan \varphi = \tan \delta \sec h$, in which δ, φ, and h are, respectively, the declination, latitude, and hour angle.

If in the second equation is substituted the definitive place of each star and the resulting latitudes are arranged in order of magnitude of the objects observed, then the values depending on the brighter stars should differ from those depending on the fainter ones, if I have a personal equation depending upon magnitude.

As soon as the observations are finished they will be discussed for the purpose above indicated.

The star places secured will also be formed into a catalogue and published. It will be the first catalogue of an extensive list of stars ever observed in this country with the prime vertical transit. The positions will also be fundamental, for they will be reduced with a value of the latitude obtained from observations made with the vertical circle of close circumpolars above and below the pole.

In addition to my continuation of the investigation of the form of the pivots of the prime vertical transit with the level, mention of which was made in my last annual report, I have also made an extensive series of measurements of their relative size and form with the aid of a spherometer-caliper. The results and conclusions derived therefrom will be given in the introduction to the volume devoted to the prime vertical observations.

The reductions of the prime vertical observations from 1893 to 1899, inclusive, are now being checked.

The individual observations of all prime vertical transits have been transcribed upon reduction sheets up to October, 1901.

5-INCH ALT-AZIMUTH.

I have continued to observe with this instrument, used as a vertical circle, a list of stars selected from those recommended by the Paris conference for early observation, and which appear to need attention to improve their places as printed in the American Ephemeris. About 1,300 observations with that instrument have been accumulated, of which about 50 per cent are reduced. At present it has been necessary to suspend the complete reduction of the observations, because the flexure of the instrument must be applied to the results, and its value can not be determined until collimators are placed in position.

The continued experience with the instrument has suggested several small improvements, one of which was to place small pieces of ground glass between the circle and the source of the illumination, so as to diffuse the light when it strikes the divisions.

During the year an investigation of the division errors of the circle has been in progress, and a great many microscope readings for their determination have been accumulated.

AZIMUTH MARK FOR THE PRIME VERTICAL TRANSIT.

Orders have been given for the construction of an azimuth mark, a lens of 300 feet focus, and its bracket. The houses to cover the lens and the mark are in process of construction. This apparatus will

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serve a double purpose. In addition to giving the azimuth of the instrument before and after an observation it will also furnish the collimation.

ALT-AZIMUTH HOUSE.

In another communication I have submitted an estimate for a building for the alt-azimuth, a structure that is very much needed. The present house is a mere temporary one, and is ill suited for an instrument of such high grade. If the estimate is approved and Congress grants the appropriation, it is my intention to submit plans for a building so made that when the instrument is in use it will be practically in the open air.

A REMARK ON THE REPORT OF THE BOARD OF VISITORS.

I am constrained to call the attention of the Superintendent to the second paragraph on page 6 of the Report of the Board of Visitors for the year 1901. One who is not conversant with the facts and who reads that paragraph might, from its wording, believe the board is recommending a plan of work for the instruments under my charge that is something new.

In 1893, just after I was assigned to duty on the prime vertical transit, a meeting was held in your office, at which were present the Superintendent, the senior professor of mathematics, and myself. After a thorough discussion of the question of what line of observing should be assigned to the instrument it was decided to observe through a complete revolution of the moon's node a list of selected zenith stars. As I stated in the first part of my report, practically the work of nine years, or half of the interval for the series, is now finished, and the statement of the Board of Visitors above mentioned is simply a recommendation to do what was inaugurated by direction of the Superintendent nearly a decade ago.

During the year I remained at the Observatory all night on 173 occasions. This was necessitated by the work coming either at a late hour of the night or early in the morning, soon after daylight.

The following paper, relative to the work of the prime vertical transit, appeared during the year: Latitude and the Variation of Latitude Determined with the Prime Vertical Transit at the Naval Observatory. (Astronomical Journal, No. 503.)

Very respectfully,

GEO. A. HILL,
Assistant Astronomer in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

THE 12-INCH EQUATORIAL AND COMET SEEKERS.

SIR: I have the honor to submit the following report concerning the 12-inch equatorial and comet seekers for the twelve months ending June 30, 1902:

I was enabled to give my undivided attention to these instruments after being relieved July 30, 1901, from the charge of the 9-inch transit circle and of the computing division, which had been assigned

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to me on account of the absence of their chiefs with the eclipse expedition to Sumatra. The instruments have been put in first-class order and are doing satisfactory work. The only criticisms which I desire to note affect the driving clock of the equatorial and its positive eyepieces; the driving clock is very unsteady, as the mechanism moves too heavily.

The use of the equatorial for visitors has been continued throughout the period, 1,208 persons having been entertained on 56 nights. A large number of occultations have been attempted during the year, and considerable progress has been made in preparing elaborate tables, by which the time required for computing the predictions and results of these phenomena may be materially abbreviated. A series of micrometric measures of the distances between the satellites of Jupiter is in progress. A few observations have been taken of faint stars within the limits of the zone observed on the 9-inch transit circle for the Astronomische Gesellschaft, while a few more are still required to complete this part of that labor.

The 5-inch comet seeker has been employed by Photographer George H. Peters since November 5, 1901, during which time he has devoted a portion of 46 nights to the search for comets. Prior to the date named I had given 9 nights to that task, and Mr. C. W. Frederick 2.

Observations for Leonids were made by naked eye November 13, 14, and 15, 1901, in which I had the valuable cooperation of Prof. F. B. Littell, Computer E. I. Yowell, and Computer H. R. Morgan. One hundred and fifty-three Leonids were counted, and a careful estimate of the position of the radiant placed it very near to 15 (H.) Leonis, in approximate right ascension $9^h\ 57^m$, approximate declination $+22\frac{1}{2}°$.. The results were published in the Astronomical Journal (Boston), No. 512.

Two asteroids, Eurynome and Parthenope, were observed at their oppositions by Computer John C. Hammond, the former six times and the latter twice. I have had a small amount of assistance in observing from other volunteers, but the tasks available for the telescope would profitably employ two regular observers. The constants of the instrument have been carefully determined at different times.

In addition to the duties arising from my own department I have joined with Professor Eichelberger in examining, assorting, and indexing the past records and computations of the Observatory as far as we have been able to find them. Those of value have been disposed in large wooden cases, specially designed with reference to their contents.

The double star measures made by Computer E. A. Boeger with the 12-inch equatorial during 1900 have been published in the Astronomical Journal (Boston), No. 522.

Very respectfully,

THEO I. KING,
Assistant Astronomer in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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THE 40-FOOT PHOTOHELIOGRAPH.

SIR: During the year ending June 30, 1902, photographs of the sun have been made on 200 days. Solar spots were found on these plates on 45 days.

While the daily average of spots for the entire fiscal year is slightly less than for the preceding one, the number of days when spots were observed from October until the end of July, inclusive, exhibits a small increase above the average. This indicates that we have passed the sun-spot minimum period.

Computer E. A. Boeger continued to operate this instrument during my absence with the Sumatra eclipse expedition, until my return on July 27, when I resumed charge of it.

It had been known for some time that there was a considerable variation of the effective focus of the lens and mirror combined, due to temperature changes. This variation had been corrected to some extent by refocusing at the different seasons by changing the distance of the lens from the photographic plate to correspond to the average temperature then prevailing. It was finally determined, in order to secure the best results, to have the plate-holding attachment controlled by a micrometer screw, so that a daily setting could be made to agree with the variation of focus due to the outside temperature. This attachment was available on November 8, 1901, and a great improvement in the average definition of the photographs was soon evident. Besides this the scale readings gave valuable data for a temperature curve of the variation of the focal plane, a provisional value for which has already been worked out.

The conditions here are different from those found in an ordinary telescope, where the changes of focus due to temperature are compensated for to a great extent by the expansion and contraction of the tube in which the objective is mounted. In the photoheliograph both ends are mounted on piers without a connecting tube, so that changes of temperature in the optical parts produce their maximum effect in the variation of focus.

Respectfully,

GEO. H. PETERS,
Photographer in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

THE COMPUTING DIVISION.

SIR: During my absence in Sumatra in connection with the observation of the total solar eclipse of May 17–18, 1901, Assistant Astronomer Theo I. King was in charge of this division.

THE OBSERVATORY RECORDS.

Upon my assuming charge on July 30, 1901, all records of astronomical and other scientific work, except chronometers and time service, now in the archives of the Observatory, or which may be added to the archives, were put in charge of the head of the computing divi-

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sion, to cause the same to be systematically arranged in suitable cases and indexed or catalogued for convenience of reference.

In fulfillment of this order there have been constructed in the large room on the second floor of the main building, through which the pier of the 12-inch equatorial passes, three cases. One of these, with a capacity of 150 cubic feet, contains all the records in the possession of the Observatory pertaining to the transits of Venus in 1874 and 1882. A second one, with a capacity of 250 cubic feet, contains all the meridian work, including both original records and reductions. The third one, with a capacity of 125 cubic feet, contains the equatorial, prime vertical, meteorological, and magnetic records.

Each drawer or compartment in these cases is appropriately labeled, and when the contents make it desirable is furnished with a detailed list. A catalogue will soon be prepared.

In planning the cases, storing the records, and labeling the drawers Mr. King has been associated with me, and the degree of success with which the work has been accomplished was made possible only by his assistance.

THE REDUCTION OF OBSERVATIONS.

The observations made with the 9-inch transit circle and those made with the 6-inch transit circle are reduced to May 1, 1902, and the printer's copy for 1900 and 1901 is in preparation.

The observations made with the prime vertical transit instrument in 1893–1899 and reduced by Assistant Astronomer George A. Hill have been checked, and the printer's copy is nearly finished. The observations since 1899 have been reduced to the middle of 1901 but not checked.

Miscellaneous computations on the reduction of the equatorial observations have been made whenever requested by the gentlemen in charge of the two equatorials.

In his preparation of the History of the Fixed Star Heavens Dr. Friedrich Ristenpart, of Berlin, has found numerous discrepancies in the star positions of the Gilliss Santiago catalogues as compared with others. He has sent us a list of nearly 1,000 such cases, and these have all been looked up in the original records and the results of the investigation sent to Berlin. This investigation has been carried on by Prof. F. B. Littell.

During the examination of the Observatory records preparatory to filing them in the specially prepared cases, there were found nearly 7,000 unreduced observations made during the years 1847, 1848, 1851, and 1852 and belonging to the Washington zones, and the printer's copy of the observations made during the years 1853 to 1859, inclusive, nothing of which has been published. The final positions of the stars in this work have been included in Yarnall's Catalogue, but the observations and reductions are not accessible to the scientific world. This material would fill about 1,500 pages of the Observatory publications.

In consideration of the fact (1) that these observations should be published, (2) that the 7,000 observations of the Washington zones should be reduced, (3) that the last eight years' work with the two equatorials should be gotten ready for printing, (4) that the prime vertical work since 1893 should be published, (5) that the catalogue of the Astronomische Gesellschaft, zone -14° to -18°, observed here, should be compiled, (6) that the cataloguing of the Washington zones 1846–1852 should be undertaken, and (7) that all this work should be

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done at the earliest possible moment, I desire most strongly to urge upon you the recommendation of the committee on publications and printing, under date of December 7, 1901, that application be made to Congress for an increase of the appropriation for miscellaneous computations to $10,000.

What time we have had from other duties, Professor Littell and I have devoted to work on the catalogue of the Washington zones 1846–1852, but I have not felt justified in taking any of the computing force off the current work to assist in this.

PRINTING.

Since the last report, Volume II, Publications of the United States Naval Observatory, Second Series, Zone Observations with the 9-inch Transit Circle, 1894–1901, has been published. Three hundred and sixty-four pages of Volume III, devoted chiefly to observations of Eros and Eros Reference Stars, and 52 pages of Volume IV, Sun, Moon, and Planet Observations have been put in type.

PERSONNEL.

The following members of the Observatory force have been attached to the computing division at some time during the year ending June 30, 1902:

Assistant Astronomer Herbert L. Rice.
Computer Ernest A. Boeger.
Computer William M. Brown.
Computer John C. Hammond.
Computer Everett I. Yowell.
Computer Herbert R. Morgan.
Miscellaneous Computer Eleanor A. Lamson.
Miscellaneous Computer Clara M. Upton.
Miscellaneous Computer Charles W. Frederick.
Miscellaneous Computer Arthur B. Turner.
Miscellaneous Computer Lelia J. Harvie.

Very respectfully,

W. S. EICHELBERGER,
Professor of Mathematics, U. S. Navy,
In Charge of Division.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

REPORT OF THE DIRECTOR OF THE NAUTICAL ALMANAC.

UNITED STATES NAVAL OBSERVATORY,
NAUTICAL ALMANAC OFFICE,
Washington, D. C., July 28, 1902.

SIR: I have the honor to submit the following report of the operations of the Nautical Almanac Office for the fiscal year ending June 30, 1902:

PRINTING.

The following publications were received during the year from the Government Printing Office:

The American Ephemeris and Nautical Almanac for 1905, first edition, 1,004 copies.

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The American Nautical Almanac for 1905, first edition, 514 copies.
The American Ephemeris and Nautical Almanac for 1902, second edition, 697 copies.
The Pacific Coaster's Nautical Almanac for 1902, first edition, 1,700 copies.
The American Nautical Almanac for 1902, third edition, 1,006 copies.

DISTRIBUTION OF PUBLICATIONS.

During the fiscal year ending June 30, 1902, the sale and distribution of publications were as follows:

Title.	Sold.	Distributed.	Bureau of Equipment.	Public service.	Total.
American Ephemeris	688	389	25	563	1,665
American Nautical Almanac	2,355	1	15	308	2,679
Pacific Coaster's Nautical Almanac	1,657	1	12	58	1,728
Astronomical Papers	38	233	2	29	302

The proceeds of sales, amounting to $1,831.72, have been deposited with the Treasurer of the United States to the credit of Public Printing and Binding.

THE AMERICAN EPHEMERIS.

I have to report that the current work of this office is fully up to date, the American Nautical Almanac for 1906 being all in type and the American Ephemeris for 1906 nearly so. These volumes will be ready for issue January 1, 1903, the earliest date authorized by law.
The general arrangement and plan of the Ephemeris is the same as that for 1905.

MISCELLANEOUS.

The work on the Catalogue of Zodiacal Stars is now practically completed and is being copied for the printer.
Considerable progress has been made upon work pertaining to the construction of new tables of the satellites. Many observations have been reduced and much of the preliminary data has been tabulated.
The library is greatly in need of books of reference to replace those worn by constant use, the law prohibiting the purchase of these from the contingent fund. A small appropriation is therefore asked to supply this need.
Many changes have occurred in the personnel of the office since the date of my last report, from one to three vacancies constantly existing, due largely to the fact that the salaries are not proportional to the duties required.

Very respectfully,

WALTER S. HARSHMAN,
Professor of Mathematics, U. S. Navy,
Director Nautical Almanac.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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DEPARTMENTS OF NAUTICAL INSTRUMENTS AND OF GENERAL STOREKEEPER.

SIR: I have the honor to submit the following report of work done in the general storekeeper's department:

Requisitions have been prepared for the purchase of instruments and stores for issue to ships and naval stations and to fit out surveying parties. Instruments received have been inspected and many shipments have been made, as will appear from the following table:

Stores received and issued by general storekeeper's department.[a]

Instruments.	Received.	Issued.
Sextants:		
High grade	19	40
Squadron angles	2	16
Surveying	17	20
Octants	73	36
Parallel rulers	7	212
Deck clocks	131	157
Boat clocks	13	71
Protractors	11	20
Drawing instruments, boxes	20	30
Navigators' cases	43	86
Steel tapes	2	27
Thermometers:		
Maximum and minimum	50	48
Air and water	426	340
Psychrometers	13	40
Spyglasses:		
Quartermasters	118	190
Officer of the deck	11	124
Binoculars:		
Day	90	251
Night	106	202
Barometers, aneroid	5	66
Clinometers	9	51
Captains' reading glasses	51	47
Splines and weights	1	26
T-squares	3	17
Artificial horizons	3	24

[a] Not including surveying outfits.

The aggregate value of instruments and stores purchased during the year for general service and for surveying work amounted to $55,263.69.

Two hundred and fifty-two shipments were made during the year, invoiced at $61,979.29.

Very respectfully,

CHAS. E. FOX,
Commander, U. S. Navy,
In Charge of Departments.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

SIR: I beg to submit the following report of the work of this department for the fiscal year 1901–2:

Mr. M. E. Porter, computer, was in charge from July 1 to September 30, 1901, when Commander C. E. Fox, U. S. Navy, reported for

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duty and took charge of this department. Mr. Porter remained as his assistant until December 11, when he resigned and was succeeded by Mr. E. I. Yowell, computer, as assistant. I reported for duty on January 22, 1902, and relieved Commander Fox, Mr. Yowell remaining as my assistant until April 5, when he was succeeded by Mr. E. A. Boeger, computer, in accordance with the plan of temporary details for duty in this department. I beg to express here my appreciation of Mr. Yowell's expert and conscientious work in connection with the arduous and exacting trial of chronometers in the temperature room.

Upon taking charge of the department, and while exercising a general supervision over the trial of chronometers and watches, their issue and repair, and the operation of the time service, I overhauled the books showing the history, location, and condition of every naval chronometer, so that they are now, I think; correct and complete.

With your approval and that of the Bureau, naval chronometers loaned to other departments of the Government have been recalled for use in the naval service. Chronometers that have been in use for many years at naval stations have been withdrawn for necessary cleaning and repair and others substituted where needed. The pamphlet entitled The Care of Chronometers is being revised and enlarged for a new edition, to include the care of watches, and data have been collected, through the courtesy of the Chief Intelligence Officer of the Navy, by the naval attachés abroad regarding the care of chronometers and the conduct of time services in foreign countries.

An important change has been made, with the cooperation of the Western Union Telegraph Company, by means of which the series of telegraphic noon signals sent out over the wires from this Observatory will hereafter continue for a period of five minutes ending at noon, instead of three and one-fourth minutes as heretofore. This series agrees with that already in use on the Pacific coast, as sent out from the Observatory at the Mare Island Navy-Yard, so that the same system is now in use throughout the United States. It may be stated also that this Observatory offered to send out the same series of signals at 1 p. m. and at 2 p. m., corresponding to noon of the ninetieth and one hundred and fifth meridians, respectively, so that the entire country might receive an actual noon signal from the standard clocks of this Observatory and that at the Mare Island Navy-Yard, instead of one at noon in the Atlantic and Pacific States and at 11 and 10 a. m. in the regions where ninetieth and one hundred and fifth meridian times are used. The telegraph company, however, maintains that the rush of business on its trunk lines at these hours will not admit at present of the two extra series of signals.

The double-page plate entitled "Telegraphic time signals," published herewith, explains the series of noon signals clearly and illustrates them by means of a diagram. It is arranged in a form to be posted in telegraph offices, at time-ball stations, and wherever the signals are received. Extra copies of this plate might be printed, to be had upon application to the Observatory.

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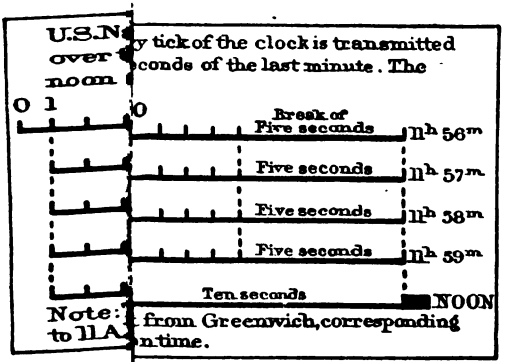
atory.

The diagram. This represents the signals a long at a uniform rate beneath it and is ctric connections of the clock are such o is listening to a sounder in a *telegraph* inute, when there is a longer interval o are in charge of time balls and of c gnal drops the time balls and corrects t



This l of five minutes immediately preceding Washington and end at noon of the 75 th meridian. For the country west of t , and end at noon of the 120th meridian, ls is corrected very accurately, shortly b transit instrument. The noon signal is s be added by the relays in use on long t me signals at other times than noon, sim nal.

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TRIAL OF CHRONOMETERS.

The usual annual six months' trial of chronometers, which did not begin till January 14, owing to delays on the part of certain makers, ended June 30, with the result that 33 out of the 41 instruments submitted passed successfully. This result, considering the long and severe test to which the chronometers are subjected, and the fact that they are all of American manufacture, is very gratifying.

The accompanying tabular statement gives in detail the actual data of the trial, and two plates are added in order to exhibit the results graphically. The attention of makers and others interested is invited especially to these plates, which serve to make the printed figures intelligible and to indicate the qualities that give chronometers the highest value for use at sea, as determined by long experience and study in the Navy of the United States.

Plate I, "Temperature rate curves," shows the rate curve for temperature of every chronometer in the trial. The number of each, placed at the point indicating the temperature of compensation (when that point falls within the limits of the diagram), is its number in order of merit, as shown in the tabular statement, and can be easily located on the plate by using the temperature of compensation given in the table. Moreover, the table gives also the rate at the temperature of compensation, so that the rate at any other temperature can be found from the plate by using the rate scale at the top and the temperature scale at the side. Of course, other things being equal, the nearer the curve approaches an up-and-down line the better. Such rate curves are sent out to navigators with every chronometer and are utilized in the navigation of every naval vessel.

Plate II, "Graphic representation of the four quantities whose sum makes the trial number," shows clearly the relative value of each of these quantities in the 33 chronometers that passed the trial. The total length of each line represents on the same scale the total trial number of that chronometer. Those of the first class, trial number from 0 to 5, are valued at $375; second class, 5 to 9, $350; third class, 9 to 16, $330, and fourth class, 16 to 25, $300.[a]

With the increase of the Navy and merchant marine, this subject is one of great and mutual importance to the Government and to American chronometer makers, and it must become a more and more important feature of the work of this department of the Observatory. Incidental to the regular use of the temperature room in this connection, for which it is admirably adapted, I beg to recommend that slight changes be made to adapt it to the simultaneous test of watches (torpedo boat, comparing, and stop watches), as well as thermometers, all of which are required in such numbers in the service as to render this thorough test very advisable, more especially as it is the only test that can be at all conclusive.

[a] There is added herewith (p. 120) a statement of the data and results of an investigation of the coefficient of time of the chronometers that passed the trial. This expression means the average daily change of rate that may be expected to take place subsequent to the middle day of the last four-week period, namely, July 21, 1902, a change additional to that due to differences of temperature and dependent upon the lapse of time only. The value of the results may be affected by the increased humidity during the latter of the two four-week periods, but may well be studied as indicating the changes that are to be expected.

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Chronometer trial, January 14 to June 30, 1902, United States Naval Observatory.

[Coefficient of time, or mean daily motion of rate curve. Data from two 4-week periods, at interval of 84 days.]

Order of merit.	Chronometer.	First 4-week period. (Four 7-day periods, No. 2 to 5, inclusive. Mean temperature, 72.60; relative humidity, 40.3 per cent.) Middle date, April 28.						Second 4-week period. (Four 7-day periods, No. 14 to 17, inclusive. Mean temperature, 79.24; relative humidity, 60.2 per cent.) Middle date, July 21.						V_2-V_1.	Coefficient of time. $\frac{V_2-V_1}{84}$
		Error.		Difference.	Mean daily rate.	Rate from curve.	Variation from curve. V_1.	Error.		Difference.	Mean daily rate.	Rate from curve.	Variation from curve. V_2.		
		Apr. 14.	May 12.					July 7.	Aug. 4.						
1	Negus, 1980	+2 6.7	+ 2 33.2	+26.5	+0.946	+1.26	−0.31	+ 3 24.7	+ 3 50.9	+26.2	+0.936	+1.29	−0.35	−0.04	−0.0005
2	Negus, 1985	−1 25.9	− 1 52.1	−26.2	−0.936	−0.90	−0.04	− 2 37.3	− 2 57.1	−19.8	−0.707	−0.98	+0.27	+0.31	+0.0037
3	Negus, 1973	−3 44.4	− 4 38.8	−54.4	−1.943	−2.25	−0.31	− 6 45.5	− 7 59.2	−73.7	−2.632	−2.14	−0.49	−0.18	−0.0022
4	Bliss, 2958	+ 6.7	+ 11.5	+ 4.8	+0.171	−0.30	+0.47	+ 0.7	− 8.8	− 9.5	−0.339	−0.30	−0.04	−0.51	−0.0061
5	Negus, 1971	+2 22.4	+ 2 34.5	+12.1	+0.432	+1.43	−1.00	+ 2 57.3	+ 3 7.4	+10.1	+0.361	+1.47	−1.11	−0.11	−0.0013
6	Negus, 1969	−1 26.8	− 1 57.2	−30.4	−1.086	−0.85	−0.24	− 3 17.8	− 4 6.3	−48.5	−1.732	−0.91	−0.82	−0.58	−0.0069
7	Bliss, 2961	+8 59.6	+10 19.2	+79.6	+2.843	+2.53	+0.31	+12 39.8	+13 45.7	+65.9	+2.354	+2.64	−0.29	−0.60	−0.0072
8	Negus, 1981	−2 50.8	− 4 16.9	−86.1	−3.075	−1.44	−1.64	− 7 22.7	− 8 53.4	−90.7	−3.239	−1.39	−1.85	−0.21	−0.0025
9	Bond, 570	+3 17.9	+ 3 31.7	+13.8	+0.493	+1.02	−0.53	+ 3 54.0	+ 4 18.7	+24.7	+0.882	+1.28	−0.40	+0.13	+0.0016
10	Negus, 1986	−1 45.3	− 2 28.5	−43.2	−1.543	−1.24	−0.30	− 3 43.4	− 4 26.3	−42.9	−1.532	−1.20	−0.33	−0.03	−0.0004
11	Negus, 1970	+5 29.9	+ 6 12.2	+42.3	+1.511	+2.67	−1.16	+ 7 38.4	+ 8 24.0	+45.6	+1.629	+2.49	−0.86	+0.30	+0.0036
12	Bliss, 2957 [a]	−2 38.4	− 4 3.9	−85.5	−3.054	−1.71	−1.34	− 7 1.3							
13	Bond, 565	+3 17.6	+ 3 51.7	+44.1	+1.610	+0.97	+0.64	+ 5 20.0	+ 6 15.3	+55.3	+1.975	+1.27	+0.71	+0.07	+0.0008
14	Negus, 1977	+2 29.2	+ 2 36.2	+10.0	+0.360	+0.59	−0.23	+ 3 13.8	+ 3 31.9	+18.1	+0.646	+0.75	−0.10	+0.13	+0.0016
15	Bliss, 2954 [b]	+5 57.2	+ 6 30.7	+33.5	+1.196	+1.91	−0.71	+ 7 27.4							
16	Bond, 569	+2 40.9	+ 3 2.7	+21.8	+0.779	+1.08	−0.30	+ 3 26.7	+ 3 43.7	+17.0	+0.607	+1.20	−0.59	−0.29	−0.0035
17	Negus, 1975	+1 51.9	+ 2 17.5	+25.6	+0.914	+0.83	+0.08	+ 3 9.4	+ 3 43.2	+33.8	+1.207	+0.98	+0.23	+0.15	+0.0018
18	Bond, 571	+2 35.6	+ 2 53.4	+17.8	+0.636	+1.01	−0.37	+ 3 25.8	+ 3 54.0	+28.2	+1.007	+1.27	−0.26	+0.11	+0.0013
19	Negus, 1910	+ 20.0	+ 1 8.7	+48.7	+1.739	+2.57	−0.83	− 34.6	+ 9.7	+44.3	+1.582	+2.89	−1.31	−0.48	−0.0057
20	Negus, 1987	+2 4.1	+ 1 39.5	−24.6	−0.879	+0.72	−1.60	+ 38.6	+ 11.4	−27.2	−0.971	+0.85	−1.82	−0.22	−0.0026
21	Negus, 1984	+5 38.7	+ 6 56.8	+78.1	+2.789	+2.44	+0.35	+ 9 1.2	+10 6.2	+65.0	+2.321	+2.70	−0.38	−0.73	−0.0087
22	Negus, 1989	+4 8.8	+ 4 50.2	+41.4	+1.479	+1.80	−0.32	+ 5 34.0	+ 5 55.5	+21.5	+0.767	+2.02	−1.25	−0.93	−0.0111
23	Geissler, 1062	− 25.4	− 1 2.5	−37.1	−1.325	−0.49	−0.83	− 1 23.5	− 1 57.5	−35.9	−1.214	0.00	−1.21	−0.38	−0.0045
24	Bond, 536	+2 1.7	+ 2 11.5	+ 9.8	+0.350	+0.38	−0.03	+ 2 24.8	+ 2 42.7	+17.9	+0.639	+0.42	+0.22	+0.25	+0.0030
25	Bliss, 2953	− 27.7	− 50.5	−22.8	−0.814	−0.05	−0.76	− 1 55.3	− 2 23.5	−28.2	−1.007	+0.41	−1.42	−0.66	−0.0079
26	Bond, 525	− 32.7	− 1 30.3	−57.6	−2.057	−0.47	−1.59	− 3 13.5	− 3 46.3	−32.8	−1.171	−0.51	−0.66	+0.93	+0.0111
27	Negus, 1983	+4 19.6	+ 4 42.2	+22.6	+0.807	+1.66	−0.85	+ 5 15.0	+ 5 31.7	+16.7	+0.596	+1.79	−1.19	−0.34	−0.0040
28	Negus, 1911	+2 42.4	+ 2 40.2	− 2.2	−0.079	+0.18	−0.26	+ 2 6.5	+ 1 39.7	−26.8	−0.957	+0.30	−1.26	−1.00	−0.0119
29	Negus, 1974	+4 33.6	+ 4 59.2	+25.6	+0.914	+2.92	−2.01	+ 6 6.8	+ 6 47.2	+40.4	+1.443	+2.82	−1.38	+0.63	+0.0075
30	Negus, 1976	+1 24.7	+ 1 13.5	−11.2	−0.400	+1.08	−1.48	+ 42.7	+ 31.3	−11.4	−0.407	+0.87	−1.28	+0.20	+0.0024
31	Geissler, 1064	− 21.3	− 1 7.5	−46.2	−1.650	−0.62	−1.03	− 2 48.8	− 3 37.3	−48.5	−1.732	−0.17	−1.56	−0.53	−0.0063
32	Bliss, 2959	+2 21.6	+ 2 20.0	− 1.6	−0.057	+1.23	−1.29	+ 2 7.8	+ 2 13.7	+ 5.9	+0.211	+1.72	−1.51	−0.22	−0.0026
33	Bond, 560	+3 40.7	+ 3 57.3	+16.6	+0.593	+1.07	−0.48	+ 4 25.0	+ 4 36.9	+11.9	+0.425	+1.58	−1.15	−0.67	−0.0080

[a] Issued to U. S. S. Montgomery July 15.

[b] Issued to U. S. S. Supply July 15.

NOTE.—The signs are astronomical: + slow, losing; − fast, gaining.

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vatory, Washington, D. C.

rates. (Orientation changed for polarity test, one week on E., W., S., and N.)

72.4	67.0	71.2	69.8	73.6	75.6	76.7	72.9
46	45	62	49	53	59	47	53
May 5 to May 12.	May 12 to May 19.	May 19 to May 26.	May 26 to June 2.	June 2 to June 9.	June 9 to June 16.	June 16 to June 23.	June 23 to June 30.
+0.99	+0.87	+1.01	+0.97	+0.94	+0.80	+1.01	+0.90
−1.01	−0.83	−0.81	−0.89	−0.71	−0.93	−0.81	−0.74
−2.07	−2.19	−2.19	−2.30	−2.16	−2.20	−2.14	−2.34
+0.11	−0.10	−0.06	−0.11	−0.19	−0.34	−0.27	−0.19
+0.41	+0.34	+0.50	+0.46	+0.57	+0.34	+0.39	+0.34
−1.17	−1.19	−1.40	−1.20	−1.43	−1.56	−1.67	−1.44
+2.91	+2.76	+2.66	+2.67	+2.61	+2.30	+2.37	+2.34
−3.20	−3.51	−3.27	−3.49	−3.19	−3.21	−3.20	−3.34
+0.33	+0.26	+0.36	+0.30	+0.49	+0.37	+0.49	+0.37
−1.33	−1.86	−1.17	−1.30	−1.16	−1.34	−1.26	−1.31
+1.53	+1.73	+1.76	+1.60	+1.51	+1.26	+1.43	+1.53
−3.13	−3.37	−3.07	−3.21	−3.16	−3.24	−3.11	−3.16
+1.60	+1.47	+1.53	+1.53	+1.64	+1.51	+1.70	+1.57
+0.33	+0.67	+0.64	+0.64	+0.70	+0.71	+0.96	+0.59
+1.11	+0.96	+1.06	+0.97	+1.11	+0.91	+1.07	+0.97
+0.64	+0.63	+0.37	+0.70	+0.44	+0.31	+0.36	+0.39
+0.96	+0.83	+0.96	+0.79	+0.97	+0.79	+0.94	+0.99
+0.60	+0.59	+0.44	+0.37	+0.60	+0.49	+0.73	+0.66
+1.46	+1.51	+1.30	+1.44	+1.49	+1.20	+1.39	+1.27
−1.04	−0.91	−0.63	−0.94	−1.11	−1.31	−1.16	−1.37
+2.47	+2.34	+2.19	+2.29	+2.29	+2.19	+2.30	+2.09
+1.39	+1.00	+0.74	+0.97	+0.76	+0.73	+0.87	+0.71
−1.51	−1.64	−1.41	−1.73	−1.49	−1.40	−1.41	−1.54
+0.29	+0.33	+0.27	+9.24	+0.29	+0.16	+0.19	−0.01
−1.01	−1.30	−1.00	−1.19	−0.83	−1.07	−1.11	−1.49
−2.20	−1.81	−1.79	−2.27	−2.00	−2.10	−1.67	−1.67
+0.69	+0.86	+0.73	+0.66	+0.61	+0.43	+0.54	+0.39
−0.24	−0.16	−0.39	−0.50	−0.61	−0.74	−0.73	−0.81
+0.97	+1.03	+1.23	+1.36	+0.74	+1.00	+1.31	+1.46
−0.53	−0.64	−0.63	−0.53	−0.47	−0.61	−0.43	−0.46
−1.49	−1.80	−1.87	−1.97	−1.73	−1.84	−1.49	−1.84
−0.07	−0.51	−0.16	−0.20	−0.16	−0.20	−0.00	−0.19
+0.47	+0.77	+0.24	+0.51	+0.47	+0.39	+0.53	+0.59
−0.31	−0.79	−0.67	−0.74	−0.49	−0.41	−0.21	−0.59
+0.66	+0.67	+0.53	+0.50	+0.67	+0.56	+0.89	+0.81
−1.27	−1.19	−1.04	−1.76	−1.46	−1.00	−0.79	−0.84
+0.31	+0.39	+0.21	+0.14	+0.07	−0.23	−0.27	−0.34
+1.19	+1.09	+1.04	+1.03	+1.24	+1.26	+1.63	+1.41
−4.13	−4.07	−4.29	−4.41	−4.44	−4.60	−4.47	−4.49
+0.59	−0.34	−0.89	−0.76	−0.94	−0.93	−0.80	−0.69
+1.36	+0.47	+1.43	+0.84	+1.40	+1.49	+1.59	+0.97

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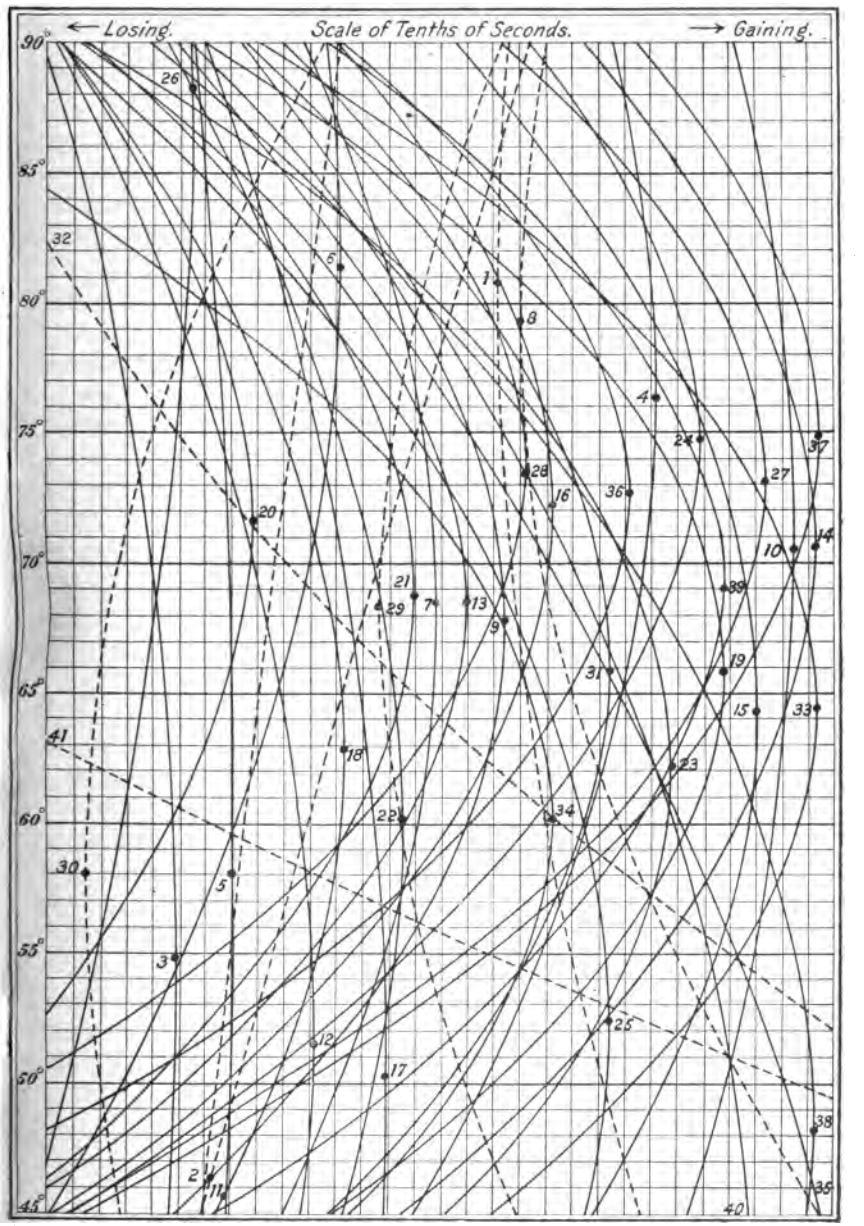

TEMPERATURE RATE CURVES, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 14 TO JUNE 30, 1902.

The numbers, in order of merit, are placed at the point on the curve indicating the temperature of compensation, when that point falls within the limits of the diagram. The dotted curves indicate overcompensation.

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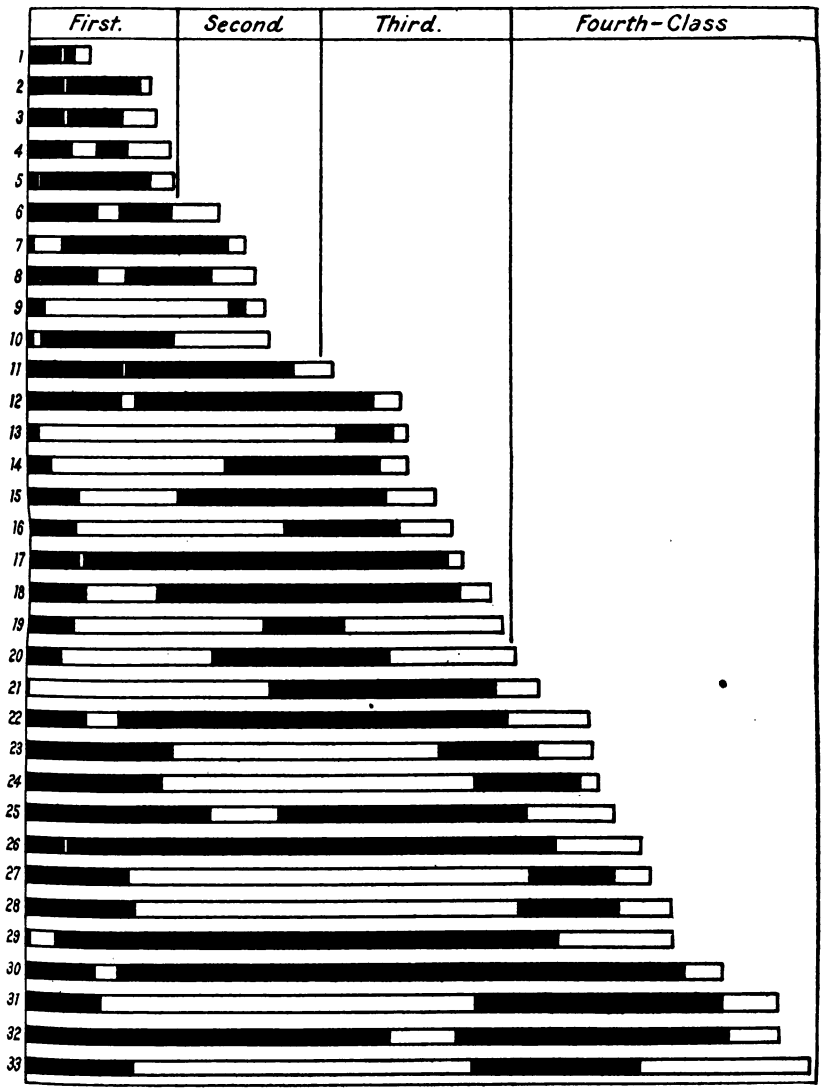
PLATE II.



GRAPHIC REPRESENTATION OF THE FOUR QUANTITIES WHOSE SUM MAKES THE TRIAL NUMBER, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 14 TO JUNE 30, 1902.

Explanation:

Temperature of compensation. | Curvature of rate curve. | Running in the temperature room. | Running in the chronometer room.

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With your approval, new sling psychrometer apparatus has been obtained for installation in both the temperature room and the chronometer room, in order to obtain more reliable data regarding relative humidity, a factor of considerable but not yet very well determined effect upon the rates of clocks, chronometers, and watches. With the data thus obtained and accurate barometric observations, I propose to continue closely to observe and study the effects of these two factors, and I think it not improbable that a correction can be determined that can be utilized practically to the benefit of the chronometers on trial, as the barometric factor is already allowed for every day in correcting the clock rates used in sending out the noon signal.

It is hoped that the next trial may begin as early as December 1 next, and that American makers of chronometers and watches will find it to their interest to cooperate even more liberally and successfully than heretofore. In so doing they may rest assured that no pains will be spared by this department of the Observatory in conducting the trial with the greatest care and impartiality and in obtaining results that are conclusive as to the relative and absolute merit of the instruments submitted. In connection with the trial, all the naval standard chronometers that have been repaired and cleaned and are available are put through the same test, and their trial rate curves and trial numbers computed like the rest for practical use in grading them in classes according to their merits for issue to naval vessels. The exactness and amount of the work and computation are of course very great, and the services of an expert computer very necessary in connection therewith. For many reasons, therefore, it would seem to be very desirable to have a permanent assistant, either a computer or assistant professor on duty in the department, who would soon become so familiar with the details of the work as to relieve the officer in charge of much of the routine and laborious duties that now occupy all of his time. Moreover, such a permanent assistant would become familiar with the inspection of other nautical instruments, a matter in which training and constant practice are of vital importance.

THE TIME SERVICE.

The series of telegraphic noon signals has been sent out regularly, except Sundays and (since March 13) holidays, with an average error of only fourteen-hundredths of a second. The computer on duty in the department has taken 145 star sights for time, using the south transit instrument. Of the three standard clocks, the Seth Thomas (mean time) was cleaned in March, and the Charles Frodsham (sidereal) in April, and all are now running very well. For the noon signal the mean of the three is used, with a slight barometric correction, resulting in extreme accuracy, and the monthly reports show that the signals are received regularly at the fourteen stations where official time balls are dropped by signal from this Observatory. In addition to these fourteen stations on the Atlantic coast, the Great Lakes, and the Gulf of Mexico, there is a time ball at San Francisco, dropped by telegraphic signal from the observatory at the Mare Island Navy-Yard, making fifteen in all for the United States—invaluable aids to navigation and commerce. The signals themselves give accurate time wherever the telegraph lines reach throughout the country. Arrangements have been made, as already stated in this report, for the series of noon sig-

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nals to go over the wires continuously for an interval of five minutes ending at noon, directly from the standard clocks at the Observatory; and the plan of omitting the twenty-ninth second of each minute, the last five of each of the first four minutes, and the last ten of the last minute enables an observer at any telegraph station to get several good comparisons of his chronometer or watch. In addition to this, more than 30,000 clocks are corrected automatically by the noon signal, and this system is being rapidly extended in all parts of the country.

CHRONOMETERS OF HISTORIC INTEREST.

To refer to a feature that has been practically ignored, owing to the constant pressure of routine work connected with the active and never-ceasing duties of the Navy, I beg to call attention to the small but interesting collection of old historic chronometers on hand, the nucleus of what I hope may become a large and important museum of great interest to visitors to the Observatory, to all friends of the service, and to the great numbers of people who attend world's fairs and similar gatherings where the Navy Department has an exhibit. Among these historic relics I need only mention a few in order to illustrate the value and interest that attaches to them, intimately associated as they have been with the officers, ships, and history of the Navy.

Eggert No. 106: First American chronometer purchased by the Navy.

Negus No. 1630: With De Long on board the *Jeannette* when lost in the Arctic Ocean. Taken to the Lena Delta. Recovered by Melville.

Bliss No. 2481: Captured on board the *Florida* when cut out in the harbor of Bahia by the *Wachusett*.

Negus No. 1256: From the *Vandalia*, lost in a hurricane at Samoa.

Negus No. 1366: The chronometer of the *Polaris*, Captain Hall, lost in the Arctic. It was buried four years in the snow and then recovered and returned by Captain Nares, of the British Navy.

Poole No. 2710: Saved from the wreck of the *Rodgers*.

Dent No. 2387: Damaged on board the *Juniata* in the great typhoon off the coast of Japan, in which that vessel almost foundered.

I beg to recommend that this museum be kept in mind and added to from time to time and that old, worn-out chronometers that have done excellent service for forty, fifty, and even sixty years in the Navy, aboard ships in every ocean of the globe: that have been under the daily care and observation of officers during long years of arduous duty; that have done their quiet, but important, part in the navigation of every class and type of ship, in calm and storm, in peace and war—I recommend that such worn-out but interesting old chronometers be added to the museum, their records written up, a just pride taken in them, and that they be no longer condemned to be sold for old junk and their history and records forgotten. Such a museum, either here or at the Naval Academy, would be an unfailing source of interest and inspiration, and it might well be given an educational value as well, by combining with it a collection of chronometer and watch movements arranged to show clearly their delicate and perfect mechanism and the steps by which their present perfection has been evolved. The makers of chronometers and watches would doubtless willingly assist in such

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a plan, for it is universally recognized that it is to the needs of navigation that the evolution of our modern accurate timekeepers is almost entirely due.

TORPEDO-BOAT WATCHES.

Reports received from abroad two years ago noted the development of a chronometer watch especially made to withstand the violent motion and vibration, as well as the high temperatures, of torpedo boats, and several of these watches were purchased for trial. An exhaustive test is now being made, under actual service conditions, of the relative value of these watches and ordinary ships' chronometers. The indications are that the watches will be found superior under the conditions mentioned, thus confirming results obtained abroad. If so, it is recommended that the policy be adopted of equipping all such vessels with these watches. The expense involved will be considerably less than for the use of ships' chronometers. The demand for this special style of watch in this country is far too small to offer any inducement to American watchmakers to make such a watch, and they will probably have to be purchased from European dealers, although a competitive trial might well be arranged in which American watches could be entered.

THE NUMBER AND ISSUE OF CHRONOMETERS.

The total number of box chronometers now in the Navy is 691, of which 553 are standards, 134 hacks, and 4 thermometrics. The care and attention involved in keeping accurate account of them, their location on ships and at shore stations, their issue and return, and their cleaning and repair, are very great, and to this is added the issue of torpedo-boat watches, comparing watches, and stop watches.

There were issued during the year 57 standard chronometers, 29 hacks, 40 comparing watches, 32 stop watches, and 2 torpedo-boat watches.

THE NEXT CHRONOMETER TRIAL.

It is recommended that the next trial of chronometers begin December 1, 1902, and that it be conducted according to the following rules for determining the trial number.[a] These are similar to those in force heretofore, but with certain slight changes intended to secure a better relative test of merit:

The merits of each chronometer will be determined by trial number, which shall be derived from the following formula:

Trial number $= p\,(70^\circ - \theta) + (1000z)^2 + 100V_o^2 + 100V_o'^2$

θ = the temperature of compensation, which is that temperature at which the chronometer runs the fastest (or, in case the chronometer is overcompensated, the slowest). The expression $(70^\circ - \theta)$ means the difference in degrees between 70° F. and the temperature of compensation, and this quantity is always taken with the positive sign.

z = the temperature constant, being the change of rate for a change of 1° in temperature from the temperature of compensation.

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[a] This recommendation was approved by the Superintendent and adopted by the Bureau. The new rules will therefore govern the next trial.

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p=a factor depending on z for its value, and is taken by interpolation from the following table:

For z=0.00000	p=0.0000
0.00025	0.0625
0.00050	0.1250
0.00075	0.1875
0.00100	0.2500
etc.	etc.

In other words, there is an increase of 0.0025 in the value of p for each increase of 0.00001 in the value of z.

The temperature rate curve, showing the effect of temperature on the chronometer's rate, is computed from the following formulæ:

$$\theta=\frac{(b-c)\,(d^2-e^2)-(a-b)\,(e^2-f^2)}{2[(a-b)\,(f-e)-(b-c)\,(e-d)]}$$

$$z=\frac{(a-b)}{(\theta-d)^2-(\theta-e)^2}$$

$$r=a-z\,(\theta-d)^2=\text{rate at } \theta^\circ$$

a=rate at d. d=lowest temperature, taken as 55°.
b=rate at e e=middle temperature, 70°.
c=rate at f f=highest temperature, taken as 85°.

The curve is constructed by computing the rates of the chronometer for every 5° of temperature from 90° to 50° from the formula $r'=r+z\,(\theta-\theta')^2$, where r'=rate at temperature θ'. The curve is plotted, using the temperatures as ordinates and corresponding rates as abscissæ.

V represents the running in the temperature room. It is determined for each period by computing the difference between the observed rate and the curve rate at that temperature. Ten periods of one week each.

V_o^2=the mean of the sums of the squares of these differences, giving those at 85°, 70°, and 55° three times the weight of those at 90° and 50°.

V′ represents the running in the chronometer room. It is determined for each period by computing the difference between the observed rate and the curve rate at that temperature, finding the mean of these differences and, finally, the variation between this mean and each difference. In other words, the rate curve is moved to the right or left to best agree with the rates observed in the chronometer room, and the variations from this new curve are then obtained. Twelve periods.

$V_o'^2$=the mean of the sums of the squares of these variations, giving equal weight to each.

Very respectfully,

EDWARD EVERETT HAYDEN,
Lieutenant-Commander, U. S. Navy,
In Charge of Department.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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REPORT

OF THE

SUPERINTENDENT

OF THE

UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1903.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

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REPORT

OF THE

SUPERINTENDENT OF THE NAVAL OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., September 1, 1903.

SIR: I have the honor to submit the annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1903:

PLAN OF WORK.

The plan of work has been in the main that specified in the order of March 6, 1846, from the Hon. George Bancroft, Secretary of the Navy, to the Superintendent Naval Observatory, as contained in the clauses: "I approve your course in making the series of astronomical observations necessary for the preparation of the Nautical Almanac" and "the country expects also that the Observatory will make adequate contributions to astronomical science." These instructions have been amplified from time to time by the Navy Department, and it has ever resisted a departure from this well-established plan.

First, to secure observations necessary for the preparation of the Nautical Almanac;

Second, to contribute to astronomical science.

PERSONNEL.

The following changes among the officers and employees have occurred since the last report:

Capt. Colby M. Chester, U. S. Navy, relieved Capt. Charles H. Davis, U. S. Navy, as Superintendent, November 1, 1902.

Commander Charles E. Fox, U. S. Navy, was detached for sea service August 20, 1902.

Professor of Mathematics T. J. J. See, U. S. Navy, was detached from the Observatory and ordered to the United States Naval Academy September 20, 1902.

Professor of Mathematics Milton Updegraff, U. S. Navy, was detached from the Observatory and ordered to the United States Naval Academy September 20, 1902.

William D. Horigan, librarian, was promoted from class 1 to class 2 July 1, 1902.

Robert H. Coker, clerk, was promoted from class 1 to class 2 July 1, 1902, and was discharged on account of disability May 31, 1903.

W. W. Dinwiddie was transferred from assistant on the great equatorial to assistant in spectroscopic work July 1, 1902.

Charles W. Frederick was transferred from miscellaneous computer to assistant on the great equatorial July 1, 1902.

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Agnes P. R. Auhagen, stenographer and typewriter, was transferred from the Nautical Almanac Office to the Naval Observatory July 1, 1902.

E. A. Boeger was promoted from computer to clerk class 2 June 1, 1903.

Eleanor A. Lamson was promoted from miscellaneous computer to computer June 1, 1903.

Lelia J. Harvie was employed as miscellaneous computer during July and August, 1902.

Etta M. Eaton was employed as miscellaneous computer from November 1, 1902.

John R. Benton was employed as miscellaneous computer from November 5, 1902.

Ella A. Merritt was employed as miscellaneous computer from December 4, 1902.

Samuel F. Rixey was employed as miscellaneous computer from December 19, 1902, to June 1, 1903.

D. T. Wilson was employed as miscellaneous computer from February 2, 1903.

Charles E. Yost was employed as miscellaneous computer from June 15, 1903.

D. R. Nihion, fireman, was transferred to the Treasury Department February 1, 1903.

S. F. McMahon, fireman, was appointed February 2, 1903.

The astronomical force has been gradually diminished year by year, first by the detachment of a number of line officers who were formerly assigned positions as observers, and more recently by the detachment of several professors of mathematics for duty at the Naval Academy. This not only left the Observatory short-handed, but made frequent rearrangements of the personnel necessary. Each new assignment to astronomical duty retards the work, breaks up its continuity, and diminishes the output. It is such changes as these among subordinate officers who have special work to do that produce confusion, as in the case of every other executive branch of the Government; not, as is frequently maintained, the change of the head or administrative officer. He must necessarily continue the policy left by his predecessor until experience has demonstrated the wisdom of innovations.

The present organization is as follows:

1. Division of meridian observations, including the 9-inch and 6-inch transit circles, the clock vault, the clock room, all clock and chronograph circuits (except those of the time service), and the whole clock system used in meridian work. This division also includes meteorological observations.

2. The alt-azimuth and prime vertical transit instruments, including their clock and chronograph system.

3. The 26-inch equatorial and great dome.

4. The 12-inch equatorial and comet seekers.

5. The division of photography, including the photoheliograph and all photographic apparatus.

6. The computing division. This division comprises a head and all computers, whether of the permanent staff or pieceworkers, and performs reductions of all observations by whomsoever made, and all proof reading for publications; but heads of instrumental divisions are consulted as to methods of reduction of their own work, and at all

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times have free access to the division on matters relating to the reduction of their own observations. The order in which the work of reduction is performed is established by consultation with the Superintendent. The head of the computing division is in charge of and responsible for all records of astronomical and other scientific work, except chronometers and time service, now in the archives of the Observatory or which may be added to the archives, and will cause the same to be systematically arranged in suitable cases in his division and indexed or catalogued for convenience of reference.

7. The instrument maker, whose duties are prescribed in sections 38 et seq., page 10, of the Regulations for the Government of the Observatory. But in addition to the above he will be held responsible for all instruments stored or not in use, and will keep the inventory of the same complete to date.

8. Committee on library. The duties of this committee are defined in the Regulations.

9. Committee on editing and printing. This committee shall consist of four permanent members and the observer or writer whose work is under consideration. No volume will be sent to press and no communication of a scientific character embodying results of work performed by an individual in the line of his duty will be sent to any periodical or scientific journal until it shall have been passed upon by this committee. All work to appear in the Observatory publications, as soon as possible after it is finished, shall be gotten ready for the printer and submitted to the Superintendent, so that the committee may arrange for the issuing of successive volumes as rapidly as possible. All questions shall be settled by a majority vote.

10. Committee on plan of work. This committee shall meet regularly once a month to consider and report upon the lines of work in progress and to be undertaken upon the various instruments.

Heads of departments as above specified will, on the last day of each month, make a written report to the Superintendent on work done during the past month and programme for the ensuing month in their own departments, and the condition of the instruments under their charge.

The detail for duty in the astronomical department is as follows:

Division of meridian observations (9-inch transit circle, 6-inch transit circle): Professor Eichelberger, Professor Littell, Mr. Rice, Mr. Brown, Mr. Yowell.

Alt-azimuth and prime vertical: Mr. Hill.

Twenty-six-inch equatorial: Professor Skinner, Mr. Frederick, Mr. Dinwiddie.

Twelve-inch equatorial: Mr. King, Mr. Hammond.

Division of photography: Mr. Peters.

Computing division: Professor Eichelberger, Mr. Brown, Mr. Hammond, Mr. Yowell, Mr. Yost, Miss Lamson, Miss Eaton.

Committee on library: Professor Skinner, Professor Littell, Mr. Horigan.

Committee on editing and printing: Professor Skinner, Professor Eichelberger, Professor Littell, Mr. Hill.

Committee on plan of work: The Superintendent (ex officio chairman of committee), Professor Skinner, Professor Eichelberger, Professor Littell, Mr. Hill, Mr. King.

In addition to the drawback to efficient administration and labor

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caused by the reorganization of the personnel, most of the time of the Superintendent and staff during the latter half of the year has been given up to answering questions called forth by several investigating boards. These boards have consisted of—

(1) A board ordered by the Navy Department, composed of Rear-Admiral F. M. Ramsay, U. S. Navy, Capt. J. E. Pillsbury, U. S. Navy, and Commander C. J. Badger, U. S. Navy, "for the purpose of inquiring into and reporting upon the advisability of eliminating or transferring to other than the control of the Navy Department any of the work now performed at the Naval Observatory."

This board reported that "in the opinion of the board, the regular work of the Naval Observatory is essential to the Navy; it can be systematically and successfully accomplished only under Government control; and no portion of it should be discontinued or transferred to other than the control of the Navy Department."

(2) The General Board of the Navy, of which Admiral of the Navy George Dewey is president, to which was referred the same subject that was referred to the preceding board, rendered a similar decision.

(3) A committee ordered by the President of the United States, composed of Mr. Charles D. Walcott, chairman; Brig. Gen. William Crozier, U. S. Army; Rear-Admiral Francis T. Bowles, U. S. Navy; Mr. Gifford Pinchot, and Mr. James R. Garfield, to report upon various matters connected with the organization of the Government scientific work. The report of this committee has not yet been made public, but it also thoroughly investigated the Naval Observatory.

Added to the drain on the time of the astronomical staff incident to the above-enumerated conditions is that due to the greatly increased demand for navigational instruments for the numerous ships building for the Navy. No small portion of the labor due to this demand has fallen on the Naval Observatory. Formerly from four to six naval line officers were employed in the three departments of nautical instruments, storekeeper, and chronometers and time service. Now one lieutenant-commander is the only line officer detailed for the combined duties of all three departments. Other branches of the naval service have been supplied with additional men paid from the general appropriation "Increase of the Navy" to meet these conditions, but the requirements of this Observatory seem to have been overlooked.

Failing to procure the needed force for this important service, it has been necessary, under the Bureau of Equipment's general order to sacrifice astronomy for military duties, to assign two computers from the astronomical force to keep up with the extraordinary demands of the fleet. Further than this, as is shown in the report of the head of the department of nautical instruments, articles of equipment for naval vessels are such that the board of inspection which passes upon invoices before they are paid for must devote much time to the examination of each article, and thus not only has the fleet made an unusual number of calls on the Observatory staff, but each call has required a greater amount of time than is usual at other naval stations. It should be remembered that navigational instruments can not be passed over with the cursory inspection given to ordinary supplies for a ship, but must be subjected to a critical test of all their different parts under varying conditions, needing at times several hours to pass one item of a schedule. As the one line officer at the Observatory can not report upon the articles under his charge, professors of mathematics

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who are employed for astronomical work have been detailed to act on the board of inspection, thereby detracting from their own individual work.

Feeling as I do that the work of the Naval Observatory has been greatly handicapped by the conditions briefly outlined above, I commend to the Department the zeal of the staff as worthy of more consideration than seems to have been accorded it in the past. The members of the staff have vied with each other during the past year in doing more than was required of them, and thus have been enabled to maintain a good average of records; but such conditions can not be expected to continue. In one instance a member of the Nautical Almanac department, Mr. H. B. Evans, in addition to a full-time service in that department, has devoted a good part of three nights in the week to observational astronomy, giving to the records data of much value. Also, Mr. Hammond, a member of the computing division of the Observatory, has contributed overtime work in the search for and location of asteroids, a work that has been much appreciated by outside astronomers.

Such observations have been published in astronomical periodicals and the authors given credit for their work, thus making an incentive for additional labor.

While such work may be only incidental to naval purposes, it helps to maintain the interest of observers in a class of astronomy that is more or less a drudgery and carries out the precept of the Observatory to contribute to astronomical science. It also produces better results in routine observations.

PUBLICATIONS.

During the fiscal year ending June 30, 1903, Volume III, Publications of the United States Naval Observatory, Second Series, has been issued.

As showing the contributions to astronomy in general other than that shown in governmental publications, the following list of articles made public is submitted:

In the Astronomische Nachrichten, Nr. 3806: "Observations of the satellites of Saturn and Uranus," by T. J. J. See.

In the Astronomical Journal, No. 528: "Observations of heliometer comparison stars," by M. Updegraff and J. C. Hammond; "Observations of comet *b* 1902 (Perrine)," by W. W. Dinwiddie and C. W. Frederick; "Observations of comet *d* 1902 (Giacobini)," by W. W. Dinwiddie; "Elements and ephemeris of comet *d* 1902 (Giacobini)," by H. R. Morgan and C. W. Frederick.

In the Astronomical Journal, No. 530: "Elements and ephemeris of comet *a* 1903 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson.

In the Astronomical Journal, Nos. 531–532: "Elements and ephemeris of comet *a* 1903 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson.

In the Astronomical Journal, No. 533: "Observations of heliometer comparison stars," by M. Updegraff and J. C. Hammond; "Observations of minor planets," by J. C. Hammond; "Observations of comet *b* 1902 (Perrine)," by C. W. Frederick and W. W. Dinwiddie.

In the Astronomical Journal, No. 534: "Observations of the declination of Vesta," by George A. Hill; "Observations of the right ascension of Vesta," by Everett I. Yowell.

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In the Astronomical Journal, No. 535: "Observations of comet 1900 II," by George K. Lawton.

In the Astronomical Journal, Nos. 537–538: "Observations of comet *a* 1903 (Giacobini)," by C. W. Frederick; "Observations of Turner's 'Nova' (2387—Geminorum)," by C. W. Frederick; "Photographic observations of the minor planet (60) Echo," by G. H. Peters; "Photographic observations of minor planets," by G. H. Peters.

In the Astronomical Journal, Nos. 540–541: "Observations of minor planets," by J. C. Hammond.

In the Astrophysical Journal, Volume XVI, No. 2: "Some results of the total eclipse in Sumatra of May 18, 1901, obtained with the photoheliograph at Fort de Kock," by G. H. Peters.

The following articles have been communicated to the Astronomical Journal for publication: "Observations of minor planets," by J. C. Hammond; "Observations of comet *b* 1902 (Perrine)," by C. W. Frederick; "Observations of comet *d* 1902 (Giacobini)," by W. W. Dinwiddie; "Observations of the satellite of Neptune," by W. W. Dinwiddie.

The following papers have been read by members of the Observatory staff before scientific societies:

Before the National Geographic Society: "The work of the United States Naval Observatory," by the Superintendent, Capt. C. M. Chester, U. S. Navy.

Before the Philosophical Society of Washington, January 31, 1903: "Progress of the zone observations of the Astronomische Gesellschaft," by A. N. Skinner.

Before Section A, American Association for the Advancement of Science, Washington meeting, 1902–3: "A new method of obtaining the constant of refraction," by George A. Hill; "Instrumental constants in equatorial work," by C. W. Frederick.

Before the Astronomical and Astrophysical Society of America, Washington meeting, 1902–3: "The photoheliograph of the United States Naval Observatory, its use and defects in solar photography," by G. H. Peters.

Favorable comment has been made of these contributions from a number of sources. One leading astronomer of the country, writing to the Observatory concerning them, states:

> He is doing valuable work in this field, and in fact the general activity of the Naval Observatory is something that astronomers must appreciate and take comfort and pride in.

As the public has been led to believe that the Observatory has no friends outside of its own department I have collected these bits of contrary sayings with much satisfaction.

BRANCH OBSERVATORIES.

That this Observatory is essential to naval purposes is well established by the reports of the several Boards to which reference has been made, and it is also the best adapted by equipment and location for the combined work upon which it is engaged, viz; navigational astronomy, publication of the Nautical Almanac, care and issue of navigational instruments, magnetic work, and the time service. A central station where Navy chronometers and other navigational instruments may be standardized is a prerequisite to best results. Chronometers in particu-

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lar must be regulated by a common standard, and should be treated by the same persons who transmit all over our country the standard time required to be maintained by them. Other countries provide for a number of naval observatories to do the work which our Washington Observatory is doing practically alone. France, for instance, has a great central observatory at Paris and branch naval observatories at Toulon, Lorient, Cherbourg, and Rochefort. A combination of their several staffs it is thought might better subserve the interests of the Navy. Many separate institutions of this kind would not only add to the expense of maintenance, but would tend to irregularity in methods and loss of efficiency in results. For instance, the temperature room of the Naval Observatory, where between $30,000 and $40,000 worth of chronometers are regulated during a period of six months in each year and many others all the year around, was designed as the result of many years' experience and study by many officers at the old Observatory, was built with the new building and is an essential part of it. To duplicate such a room, even without a transit house and clock room (which are really essential, as each depot of this kind ought to be complete in itself), and to provide the expensive apparatus required for the exact work of the inspection of other nautical instruments, would cost in the neighborhood of $10,000. To establish such an outfit at four or five different points along our coast would nearly quadruple the first cost for plant, with a proportional increase for maintenance, while at the same time doing away with that exact comparative test and standardizing of instruments that is one of the strongest points of the present system. Transportation charges are but a small part of the expense of equipping a fleet with navigational appliances, and should have no weight in determining how or where they should be put in proper adjustment. It seems therefore not only a wise policy to have the one station at Washington to carry on this important service for the Atlantic coast, but the contrary plan is entirely impracticable. It is centralization that reduces expense and increases efficiency in all business, not decentralization. If, therefore, all naval work required of an observatory could be centered in Washington, the best policy indicates that such should be the case, but the large area covered by the present United States is a field too vast to be controlled exclusively at one point. Hence we have a small naval observatory at the navy-yard at Mare Island, Cal., from which the naval vessels in the Pacific can receive their supplies of navigational instruments (first standardized at Washington), and which shares with the parent institution at Washington the furnishing of time to the country, which for this purpose is divided into two grand time divisions by the Rocky Mountains; Washington has charge of the eastern section and Mare Island of the western.

But there is an extension of this work that is necessary and is becoming more so as the country grows. This was indicated in my communication to the Bureau of April 4, 1903, wherein was recommended the establishment of a small observatory at the naval station, Tutuila, Samoa, for the purpose of observing a list of 500 of the 1,597 stars adopted for publication in the nautical almanacs of the United States, Great Britain, France, and Germany, at a conference of the directors in 1896; for the accurate determination of time for the use of navigators in that far distant section of our national domain; and for the determination of the magnetic elements, a knowledge of which is so important to navigation.

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Similar observatories elsewhere can be established with much benefit to our naval and commercial interests without material expense to the Government. Such points as the island of Guam, the Philippines, Hawaiian Islands, and Midway Island, where naval stations must be maintained, afford excellent opportunities for carrying on such work as the Navy requires, and this work can be done by its officers to their own and the Government's advantage. In fact, such an observatory as proposed has existed at Guam since soon after its occupation by the United States naval forces in 1898, but it should be reorganized and its work harmonized with that of the central and parent station, and made to conform to a general plan of operations.

The station at Tutuila, situated in latitude 15° south, longitude 168° west, is simply an ideal location for astronomical observations, and this is recognized by leading astronomers of the country. It has a field almost entirely undeveloped, and the heavens covered by its telescopes contain a large portion of the stars desired for use of the Nautical Almanac, and which in the near future will become important in navigation among the islands of the Pacific and other southern oceans of the globe.

As stated in the Observatory's letter referred to, there being required at the Tutuila Naval Station at all times a naval vessel with a full complement of officers, observations in astronomy and magnetism can be carried on by them, some of whom may have been employed on similar duties at this station. But, in view of the great scarcity of naval officers at this time and the necessity of employing the few now attached to the station vessel in the survey going on in the Samoan group, for which a small observatory is particularly essential, I respectfully recommend that one of the assistants be detailed from this Observatory to proceed to Tutuila, set up the instruments that have recently been sent there under orders from the Bureau, and make the observations which are necessary to complete the list of stars called for by the International Commission of Nautical Almanac Directors.

There will be found at the naval station at Tutuila, for carrying out this important plan, the following instruments:

1 barograph.
1 Mascart clock and vertical force magnetograph.
1 set of Kew magnetographs, with clock, telescopes, and scales.
1 declinometer and scale.
1 theodolite and collimator.
1 dip circle.
1 magnetometer.
1 transit circle.
1 chronograph.
1 thermograph.
1 Riefler astronomical clock.
1 photographic outfit and supplies.
1 box of books, record sheets, etc.

I am sure that the commandant of this distant station, Commander E. B. Underwood, U. S. Navy, would greatly appreciate the assistance of one of the young men of this Observatory in executing the work proposed, and that this fascinating field for observational astronomy would call forth the best services of the fortunate man designated for the duty.

MACHINE SHOP.

For a long time there has been felt the want of a shop at the Naval Observatory where slight repairs at least for the large number of instruments under the Observatory's control could be made. It has

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been necessary to employ an instrument maker who could examine intelligently the appliances for astronomical observations and keep them in order, but he has had very meager appliances for making repairs. Much thought has heretofore been expended in trying to devise a machine shop, but the cost of its installation dealing with figures entirely too large for the regular appropriations was always a bar to such an establishment.

Through the courtesy of Rear-Admiral Melville, Engineer-in-Chief of the Navy, a number of machines which were obsolete for naval purposes, but which were good enough for the slow and delicate work of repairing instruments, were loaned to the Observatory.

With these machines Mr. W. W. Dinwiddie, assistant in spectroscopic work, has installed a very respectable machine shop. It has only recently been completed, but already its advantages are apparent. It is thought that in the future a marked saving in expense can be made in doing repairs to instruments, and also that the shop will furnish facilities for experiment and improvement and the construction of new apparatus. Mr. Dinwiddie by his mechanical ability has greatly improved the lighting system of the instrument on which he is an observer—the 26-inch equatorial. The photographic camera which he has attached to the telescope has also been very useful in the search for missing asteroids. Mr. G. H. Peters, the photographer of the staff, has been thus enabled to locate these small wanderers by photography, without which means of observation it is doubtful if some of them may not have been lost from view altogether.

GROUNDS AND ROADS.

Since the last annual report one of the outlying tracts of land, consisting of 0.425 acre of ground, belonging to the heirs of Margaret C. Barber, has come into possession of the Observatory by the final passing of the title to the Government. This purchase was covered by the fund appropriated by the naval appropriation act dated March 3, 1901, for the purchase of land lying within the Observatory Circle and not included in the original purchase. There still remains to be acquired the tract belonging to Mr. Philip Young and the tract belonging to the estate of Normanstone. The owners have refused to accept the Government appraisal and appealed to the courts, and final action has not yet been secured. In addition to these two tracts there remains to be secured to complete the area originally contemplated, 6.72 acres occupied by the Industrial Home School.

The report of the Secretary of the Navy for the fiscal year ending June 30, 1901, recommended to Congress the acquisition of this last piece of property, and the Superintendent was directed by the Department to place himself in communication with the secretary of the District Board of Charities and seek to reach an agreement by which a proper compensation could be determined for this land. My predecessor executed the commission, but found it impossible to reach an agreement, and recommended that this question be referred to a board of appraisers. I respectfully renew this recommendation.

I have had occasion to call the attention of the District Commissioners to the unsanitary conditions prevailing in these grounds, wherein a considerable area of land was set apart for a sewage bed, the refuse draining into the Observatory grounds. The sewerage system of the

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school has at last been connected by pump to the main sewer of the Tenleytown road, but the sewage bed is still left as a breeding place for insects, which are blown by the prevailing summer winds into the quarters of the Observatory staff. As the Observatory was removed to its present site in 1893 owing principally to the unsanitary conditions prevailing at its former location, it seems proper to protest against artificial conditions being maintained in its vicinity that are detrimental to health. Furthermore, as a large section of the school grounds is below the grade of the Observatory lane, the Government is at very considerable expense in making repairs to the roadbed which is frequently washed away by the waters being dammed in the adjoining property. While the question of a transfer of the school to a more suitable site is in abeyance, it is doubtful if anything will be done to abate this nuisance, of which complaint has been made, and I believe the purchase of a portion of this property, if made in the near future, would better subserve the interests of the Government than to wait an indefinite time to control the whole. I therefore recommend that an effort be made through the Board of Charities to determine the value of such a section of this land as may be needed to protect the Government's present holdings, leaving to the appraisers the determination of the question of final costs of the whole property.

The work of grading Massachusetts avenue has left the boundary lines of the Observatory property ragged and the little that is left of the fencing utterly useless. I renew the recommendation of my predecessor that a suitable fence be provided for in the next appropriation bill to completely inclose all the land belonging to the Observatory.

There will also be needed at the same time the full allotment of $10,000, heretofore allowed, to adjust the roadbeds within the grounds to the street line adjacent to the circle. Estimates for the above have been submitted for the next appropriation bill. As was stated in the last annual report, the appropriation of $5,000, allowed the last and the present fiscal years, is only sufficient for the care of grounds, leaving but very little for the work of grading.

As was also stated in the last annual report, when Massachusetts avenue becomes a thoroughfare the Observatory grounds will form one of the most beautiful parks in the city of Washington. By the time the next appropriation becomes available the District government will probably have completed their share in making the place attractive, and it remains for the United States Government to carry into effect a broad plan that will utilize to the utmost the great natural beauties of the grounds.

PUBLIC BUILDINGS.

Partly with the deficiency appropriation requested for the purpose, and provided for in the act of Congress dated March 3, 1903, all the iron and wooden buildings of the station have been thoroughly painted during the past spring and are now in good condition. The interior walls of the main building have also, for the first time since the building was constructed, been given the painting they very much needed. Thus the appearance and sanitary conditions of the offices have been improved, and the housing of the instruments, where iron construction is used, has been protected from serious deterioration.

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BOARD OF VISITORS.

Congress made no appropriation the past year for the expenses of a board of visitors created by the act dated March 3, 1901, and I think that the discontinuance of such a visiting committee thus prohibited is in no wise detrimental. The work of the Naval Observatory is largely practical and is of a character not common to those educational institutions devoted exclusively to research in astronomy, and therefore civilian astronomers engaged in such institutions are not, as a rule, as good judges of this Observatory's requirements as are the executive officers who direct its management and to the largest extent use the data furnished. The staff of the Naval Observatory has among its membership quite the peers for age and experience of any other observatory of the country, and they are fully able to cope with the problems in astronomical science that such an institution as this is called upon to discuss. History will show that of the number of astronomers who have become eminent in this branch of work the Naval Observatory has contributed quite its share of able men who first learned their profession here, or if they did not learn it, gained largely the experience which enabled them to take a prominent stand in scientific research. At the present time the Observatory has within itself a club or small astronomical society wherein, at weekly meetings (outside of office hours), all the literature of the day pertaining to astronomical research is reviewed and discussed by its members. This method of becoming thoroughly acquainted with the present state of astronomical science furnishes a much better basis for planning the future work of the Observatory than can be obtained from consultation with the limited number constituting the board of visitors during the few hours devoted by them to the inspection of the Observatory. Moreover, the members of the staff are, as a rule, active participants in the assemblies of the American scientific associations, and thus gather information which can be used for the betterment of methods and are not forced to consider questions which are by their very nature stamped as impracticable. As evidencing the unreliability of suggestions submitted, based upon imperfect knowledge, reference is made to the following extracts, which explain themselves:

[Extract from report of Board of Visitors to Naval Observatory, 1901.]

As examples of special researches that might have been taken up under such a system may be mentioned the comparison stars for Victoria and Sappho proposed by Doctor Gill in 1889, and the comparison stars selected by the Astrophotographic Conference of 1900 for observations of Eros.

[Extract from Superintendent's report, 1902.]

This leaves the clear imputation that this work has not been done at the Observatory. In point of fact, not only have all these observations been made but those of the comparison stars for Victoria were actually made in part by a member of the board of visitors, then an assistant at the Naval Observatory. His signature occurs in the original record books of this work. The Observatory holds the official receipt of Doctor Gill, and Doctor Gill himself publicly acknowledges this member's share of the work. (A Determination of the Solar Parallax and the Mass of the Moon, by David Gill, LL. D., etc. Annals of Cape Observatory, Vol. VII, p. 559.) This single example is a vivid illustration of the attitude of the board of visitors toward the Observatory. Nor is this the only instance of the board's ignoring work actually performed, with a similar imputation.

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UNIVERSITY OF MICHIGAN, ASTRONOMICAL OBSERVATORY,
Ann Arbor, May 26, 1903.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

SIR: Referring to the last report of the Superintendent of the Naval Observatory, and to that part in which the board of visitors is criticised for stating that observations might have been made at the Observatory of the Victoria and Sappho comparison stars when they actually had been made, I regret very much that such a slip occurred. Now I remember about taking part myself in the observations. These were made some twelve years ago under the direction of Professor Eastman, who, of course, planned the work for his assistants.

The report of the board of visitors was made up of the reports of separate committees, the portion referred to coming from the committee on scope of work and organization, of which I was not a member. Managing in this way, it was almost necessary to assume that all statements of fact had been verified by the proper committee. I certainly did make this assumption. Moreover, the scheme of work is put in the report in a tentative way for further discussion.

Very respectfully, A. HALL, Jr.

TOTAL SOLAR ECLIPSE OF 1905.

There will occur on August 30, 1905, a total solar eclipse, one of those important events in which the Naval Observatory has always taken an active interest. Already astronomers in Europe and America have begun to prepare to observe this interesting phenomenon, and I have submitted an estimate which will allow the Government to take its usual part in what has become a recognized affair of state among the principal nations of the world. As is generally the case, the section covered by this eclipse of the sun is not near our doors. With the large area covered by the United States we have more than our share of such visitations, but in this case, as in the last important eclipse of the sun, it is necessary to go afield to observe it.

Spain seems to be the best country in which to observe the coming eclipse, for there it has a length of totality of over three and one-half minutes and occurs near midday, when the sun is high in the heavens, thus affording favorable atmospheric conditions.

It is extremely desirable that the Naval Observatory should take its usual share of the work incident to this important event, but it is questionable if it is wise to detach such a large number of the staff to act as observers as has been customary heretofore, even if economical reasons did not force themselves into the issue. I believe that the English plan of observing eclipses would procure better results at less expense. The Admiralty, recognizing the great importance to science, has established a practice of detailing a vessel of the English navy to form the basis of an expedition to observe eclipses of the sun.

Sir Norman Lockyer, in writing of the contribution of the English navy to science, has said:

> It has long been one of the glories of the British navy that, more than any other, it has been employed in exploration and investigation, and in this way has done service to mankind by promoting the arts of peace.

And further:

> Without the assistance of the officers and men of H. M. S. *Melpomene* our work at Viziadrug (observing the eclipse of 1898) could not have been done.

The same might be said of our own service and of the U. S. S. *General Alava*, which carried the Naval Observatory party from Manila to Sumatra in 1901. The history of the Navy will show the important part assigned to our ships and officers heretofore, but as the utilitarian purposes of eclipses are for the Nautical Almanac, I would

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suggest that the crews be used as a body in observing them. Not only can our ships be used as transports, but their well-drilled complement of officers and men should in the main handle the instruments for observations. It is thought that one of the vessels of the European Squadron could, say for the month of August, 1905, be spared to prepare for and take part in the observation of the total eclipse which occurs on August 30 of that year in Spain.

I have already been engaged in a preliminary study of the path of totality crossing the Spanish peninsular, and am assured by prominent astronomers of that country of a cordial reciprocity of ways and means for carrying on the work. Such a naval expedition would, I am convinced, be of marked political benefit to the two countries, and the time would be opportune to associate ourselves with the Spanish people on a peaceful mission of this character. I shall later submit a plan in detail for carrying out this desirable object. At present I briefly refer to the subject as a means of calling attention to the moderate amount of money called for in the estimates and to explain that it is based on the use of the personnel of one of our men-of-war for making a large share of the observations, as well as the ship herself as a station ship. It will then be necessary only to send a small number of experts from the Observatory to act as instructors and directors in the work. As thus organized most of the money estimated for may be used for the purchase of new instruments. Those which were formerly used were constructed for the Transit of Venus Expedition in 1874 and 1882. They are now obsolete and worthless for scientific purposes.

REPORTS OF HEADS OF DEPARTMENTS.

As the detailed reports of the different heads of departments are submitted herewith, it does not seem necessary to state more than that the plan of work therein described was prescribed by the Superintendent's orders and the results meet with his approval.

Very respectfully, your obedient servant,

C. M. CHESTER,
Rear-Admiral, U. S. Navy,
Superintendent of the Naval Observatory.

The CHIEF OF THE BUREAU OF EQUIPMENT,
Navy Department.

THE 26-INCH EQUATORIAL.

SIR: I have the honor to submit the following report on the work of the 26-inch equatorial during the year ending June 30, 1903:

The 26-inch equatorial was in charge of Prof. T. J. J. See, U. S. Navy, from July 1, 1902, to September 20, the date of his detachment from the Observatory, when I was placed temporarily in charge. On October 14 I was formally transferred from the division of meridian observations to assume charge of the 26-inch equatorial.

At the time of his detachment Professor See had nearly concluded a series of observations of the satellites of Saturn, which was suspended, as it was not thought best to complete it with a different observer.

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The distribution of the work of the instrument among the observers has been as follows: Professor Skinner, double stars and variable stars; Mr. Dinwiddie, the satellites of Neptune and Uranus; Mr. Frederick, the satellites of Saturn. Both Mr. Dinwiddie and Mr. Frederick have made observations of comets and asteroids. Photographs with the Dallmeyer camera mounted on the telescope have been made mostly by Mr. Peters and a few by Mr. Dinwiddie.

I have necessarily devoted a large amount of my time during the year to work in connection with the preparation of the catalogue of the Astronomische Gesellschaft zone $-13^\circ\ 50'$ to $-18^\circ\ 10'$, which work is referred to in greater detail by Professor Eichelberger in his report on the computing division.

STATE OF THE INSTRUMENT.

The instrument is in excellent working condition. During the year just closed a new system of electric wiring has been installed in the 26-inch equatorial building. A switch board has been placed in the hall to control all the lights in the building. From this board a circuit is run to a second switch board on the elevating floor, which controls all the lights in the dome and on the instrument. The 110-volt commercial lighting circuit is now used for everything, thus doing away with the batteries formerly employed for the micrometer lamp. Standard lamps have been substituted for the special lamps heretofore used in the illumination of the circles and the micrometer. Resistances for varying the brightness of both sets of threads of the micrometer are placed under the floor and controlled by rheostat switches on the switch board. This system of wiring was planned and installed by Mr. Dinwiddie.

It is highly desirable that an electric motor be provided for turning the 45-foot dome, and also that some scheme may be devised for operating the automatic electric winding apparatus of the telescope driving clock, which has been useless since the introduction of the alternating electric current. The adoption of these labor-saving devices will tend to improve the quality of the observing by lessening the expenditure of energy required in operating the instrument and its accessories.

OBSERVATIONS OF SATELLITES.

The satellites of Mars.—The conditions during the opposition of Mars of 1903 were unfavorable both from the position of the planet and from the atmospheric conditions, and no satisfactory observations could be obtained.

The satellites of Saturn:	Observations.
Tethys-Mimas	31
Tethys-Enceladus	38
Dione-Tethys	46
Rhea-Tethys	38
Titan-Tethys	32
Iapetus-Tethys	23
Rhea-Dione	28
Titan-Rhea	44
Hyperion-Titan	22
Iapetus-Titan	29
Total	331

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	Observations.
The satellites of Uranus:	
Titania	29
Oberon-Titania	28
Oberon	25
Total	82
The satellite of Neptune	18

OBSERVATIONS OF COMETS AND ASTEROIDS.

Comets:	
b 1902 (Perrine)	41
d 1902 (Giacobini)	22
a 1903 (Giacobini)	14
Total	77
Asteroids:	
Honoria (236)	3
Chicago (334)	3
Roberta (335)	3
Chloe (402)	2
Total	11

MISCELLANEOUS OBSERVATIONS.

During the year 2 measures were made of the diameter of Vesta, 3 observations of comparison stars for comet *b* 1902, 240 observations of double stars, and 42 observations of variable stars.

The Dallmeyer camera.—Twenty photographs have been taken with this camera, principally for deriving from them places of asteroids to facilitate observations with the 26-inch and 12-inch equatorials.

The total number of observations, including photographs, made during the year, as shown by this report, is 823.

The amount of work done on the instrument has been materially influenced by the notably unfavorable weather for astronomical work which has prevailed during a large part of the year.

The constants of the instrument.—Mr. Frederick has devoted much time to the development of methods and the determination of the constants of the instrument at frequent intervals during the year. He has made 30 determinations of these constants and has shown that the instrument possesses a very high degree of stability.

Differential refraction.—Mr. Frederick has been engaged in preparing tables for correcting observations made in this latitude for differential refraction. One set of these tables is arranged for differences of right ascension and declination, and the other set for position angle and distance. The computation of these tables, which are about one-half completed, has entailed a large amount of labor.

PERSONNEL.

T. J. J. See, professor of mathematics, U. S. Navy, in charge July 1 to September 20, 1902, the date of his detachment from the Observatory.

A. N. Skinner, professor of mathematics, U. S. Navy, temporarily in charge September 20 to October 14, 1902. In charge from October 14, 1902.

W. W. Dinwiddie, assistant in spectroscopic work.

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C. W. Frederick, assistant on the 26-inch equatorial.
Gustave Harrison, laborer.

I desire to call special attention to the faithfulness and skill of Mr. Harrison in the performance of his duties, which require an order of intelligence much above that of laborer. I take pleasure in recommending him for promotion should opportunity offer.

Very respectfully,

A. N. SKINNER,
Professor of Mathematics, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

THE DIVISION OF MERIDIAN OBSERVATIONS.

SIR: I have the honor to submit the following report on the work of the division of meridian observations for the fiscal year ending June 30, 1903:

The division of meridian observations was in charge of Prof. A. N. Skinner, U. S. Navy, until October 14, 1902, at which date I was placed in charge.

THE 6-INCH TRANSIT CIRCLE.

This instrument has been used throughout the year for making observations of the sun, moon, planets, and miscellaneous stars, under the direction of Prof. F. B. Littell, U. S. Navy. The plan has been to have this work carried on by three observers. Those engaged in the work during the year are Prof. A. N. Skinner, U. S. Navy, until October 14, 1902; Prof. F. B. Littell, U. S. Navy; Assistant Astronomer H. L. Rice, and Computer W. M. Brown.

Prof. M. Updegraff, U. S. Navy, until his detachment on September 20, 1902, assisted by Computer J. C. Hammond, made observations on selected lists of zodiacal stars furnished by Sir David Gill. The observations that had not been secured up to this date were made later by Computer J. C. Hammond, assisted by Computer H. R. Morgan. All these observations were made on the 6-inch transit circle at times when it was not needed for the regular sun, moon, and planet work.

The number of observations from July 1, 1902, to June 30, 1903, is as follows:

Ephemeris stars	2,284	Juno	1
Sun	138	Pallas	5
Moon	139	Vesta	8
Mercury	57	Isis	1
Venus	110	Zodiacal stars	872
Mars	29	Screen stars for personal equation	128
Jupiter	10	Stars for inclination	24
Saturn	13	Miscellaneous stars	40
Uranus	14		
Neptune	15	Total	3,898
Ceres	10		

THE 9-INCH TRANSIT CIRCLE.

The repairs spoken of in the annual report of last year have been completed, the great difficulty experienced in obtaining satisfactory

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steel for the new pivot rings having delayed this completion many months.

The divisions of Circle B, regraduated by Mr. George N. Saegmüller in 1893, but which has not been used since that date, have been refilled by Mr. Saegmüller.

The illumination of the field of the telescope is now effected by means of a small mirror cemented centrally upon the outer face of the object glass, thus securing axial instead of the former unsymmetrical oblique illumination. The prism which formerly, receiving the light as it entered through the hole in the pivot, reflected it upon the field of the telescope micrometer has been turned around so as to throw the light upon the small mirror on the object glass. While this small mirror was being adjusted so that the light would be thrown axially down the telescope tube, it was impossible to secure sufficient brilliancy of field with the old sources of light, a Welsbach gas burner and an ordinary 32-candlepower incandescent electric lamp. A satisfactory source of illumination was found in a 50-candlepower Nernst incandescent electric lamp. During the experiments with the illumination it was discovered that stray light was thrown upon the field of the micrometer from the sides of the telescope, so that another diaphragm must be inserted.

Each reading microscope is now provided with an individual electric lamp for illuminating the circle.

A slight inequality of the pivots was revealed by the use of the spherometer-caliper and a series of measures with an axial collimator for the determination of their irregularities is in progress.

A new telescope-micrometer and a new chronograph have also been provided.

The pier for the south meridian mark has been finished, and when observations are resumed with this instrument a north and a south mark will both he used.

THE CLOCK SYSTEM AND CLOCK VAULT.

A year ago attention was called to the fact that the temperature coefficient in the daily rate of the clock Howard No. 404 was $0^s.06$ per degree Fahrenheit. The clock was undercompensated, though the jars furnished by the makers were filled with mercury. As soon as I assumed charge in October correspondence with the E. Howard Clock Company was entered into, resulting in a new pendulum being ordered with longer jars. The new pendulum has been received, but as it vibrated with a wabbling motion instead of in a plane, it was returned. The makers have not yet succeeded in correcting this defect. The old pendulum to this clock also wabbles slightly.

In January there was ordered for the Observatory one of Riefler's best astronomical clocks with a nickel-steel pendulum and inclosed in a glass air-tight case. Notice has been received of its shipment from Munich, but it has not yet arrived at the Observatory.

The temperature control in the clock vault is fairly satisfactory.

Very respectfully,

W. S. EICHELBERGER,
Professor of Mathematics, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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THE PRIME VERTICAL TRANSIT AND THE 5-INCH ALT-AZIMUTH.

SIR: For the year ending June 30, 1903, the following is respectfully submitted as the report upon the astronomical work in my department:

PRIME VERTICAL TRANSIT.

The instrument has remained in practically good order during the year, but will soon need a general cleaning and a few minor repairs.

The level tube was given its periodical test in the winter months, and the results have proven the tube to be a good one. In the summer of 1893 a test was made of it and a value of 1″.14 for each division obtained. The test given on the trier in February gives as the value of one division 1″.16. It will thus be seen that in ten years the level tube has remained in a normal condition and has not changed.

The instrument has been devoted during the year to observing the close zenith stars upon the plan followed in the past, as well as securing positions of the fainter stars, mention of which was made in my last annual report. It had been expected that observations of these fainter stars would be finished late in the fall, but on account of cloudy weather a few between four and six hours of right ascension need one or two observations to complete them.

With the instrument there have been made 481 observations of transits, which has as its equivalent in the meridian, 1,924 observations. It seems proper at this time to call attention to the fact that our prime vertical has now the world's record for a continuous series of observations with that form of instrument. From July 28, 1893, to June 30, 1903, slightly less than ten years, there have been made, by one and the same observer, 1,018 observations of the passage of α Lyræ across the prime vertical, an average of slightly less than one observation every four days for that entire period. It has never been equaled by any other observatory in the world.

The reduction of the prime vertical transits are now completed to January 1, 1901, and they are entered on the reduction sheets to October 29, 1902. The chronograph record is transcribed by the observer to the observing books within a day or two after the observations have been made. He has also transcribed the original record to the reduction sheets, and then turned them over to the computing division for completion.

AZIMUTH MARK FOR THE PRIME VERTICAL TRANSIT.

The pier upon which the long focus lens is mounted, and the house to cover the same, as well as the mark and its house, have been completed during the year, and this auxiliary apparatus is now in use. The long focus lens was made by Brashear, and the mounting by the Warner & Swasey Company. The lens is of 5 inches aperture and 325 feet focal length, thus being about 0.2 of an inch larger in aperture than the lens in the transit. The pier upon which the lens is mounted is one of the marble piers upon which the collimators for the 8.5-inch transit circle were mounted when that instrument was in position at the old Observatory. It is placed upon and embedded in a concrete footing, 3 by 3 feet, and 4 feet in the ground. The top of the pier

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has a depression 10 by 4 inches cut into it, and in this has been embedded in concrete an iron plate, 1 inch thick, to which the lens mounting is secured by large anchor bolts. The face of the mounting is provided with a transverse motion, by means of a screw, and the change of the lens with respect to the mark can be read from a scale on the face of the mounting, and divided head fastened to the end of the screw. Once the lens is properly adjusted a set nut locks it with respect to the screw and prevents any accidental change of the same. The pier upon which the mark is placed is to the east of the instrument, as that direction gave promise of better conditions than to the west.

The pier is made of brick laid in cement. It is 3 by 3 feet, 3 feet in the ground and 2 feet above the same. The top of the pier is a concrete cap, 3 inches thick, in which the four bolts holding the mark are embedded. After a careful study of the absolute stability needed in this pier the observer was of the opinion that the conjunction of brick and concrete would give a mass less liable to different expansive effects than capping the pier with a marble slab.

The ventilation in the houses covering the lens and the mark appears to be very satisfactory, the houses being louvre work, yet built so that neither rain nor snow can beat into them.

The depression of the mark below the horizontal line of the telescope is 4° 24′. The line of sight from the telescope to the mark passes over the grass on the lawn, and in days of very high temperature the image appears free from a marked mirage.

ALT-AZIMUTH.

The observer has continued to observe with this instrument, used as a vertical circle, a list of stars selected from those recommended by the Paris Conference, mention of which was made in my last annual report. The selection includes all stars in that list which are not now incorporated in the nautical almanacs, and which can be observed from our latitude. I have also included all circumpolars whose north declination exceeds 80°. Of these there have been made during the year 764 observations. This gives about 30 per cent more observations than were made with the two instruments last year, and was due to the able assistance I received for about half the year, mention of which will be made shortly. In this connection it may be well to state that it occupies just twice as long to observe a star with the vertical circle as it does with a meridian circle, because each time a star is observed its zenith distance is measured over twice the arc on the circle that would be used were the observation made with the meridian circle.

On January 19, 1903, Mr. H. B. Evans, of the Nautical Almanac Office, at his own request, was assigned by the Superintendent as an assistant observer on this instrument. The plan has been for Mr. Evans to observe on three nights each week and the observer in charge on the other nights. This has not been followed in the past as strictly as it will be in the future on account of the need of finishing up the list of stars being observed with the prime vertical. However, Mr. Evans has, in a most commendable manner, put in his three nights per week, in addition to his other duties in the Nautical Almanac Office, and his tour of observing has been from three to four hours on those nights when he observed. It is unnecessary for me to say that

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I consider him a careful and accurate observer, for his work will demonstrate that.

ALT-AZIMUTH HOUSE.

The observer feels that it is proper to call attention in this report to the need of a larger house for covering the instrument. The present one, as is known, was intended only as a temporary house, and it is not adapted to the needs of the instrument.

Very respectfully,

GEO. A. HILL,
Assistant Astronomer, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

THE 12-INCH EQUATORIAL AND COMET SEEKERS.

SIR: The operations with the 12-inch equatorial telescope and comet seekers during the twelve months ending June 30, 1903, are tabulated herewith:

Measures of diameter of Venus	2
Measures of diameter of Mars	10
Measures of diameter of Neptune	16
Measures of Jupiter's satellites	34
Observations of the phenomena of Jupiter's satellites	13
Observations of asteroids:	
(6) Hebe	4
(9) Metis	5
(11) Parthenope	4
(12) Victoria	5
(16) Psyche	5
(17) Thetis	5
(18) Melpomene	4
(20) Massalia	5
(24) Themis	3
(29) Amphitrite	5
(39) Laetitia	5
(42) Isis	1
(43) Ariadne	2
(60) Echo	5
(68) Leto	5
(69) Hesperia	4
(79) Eurynome	4
(83) Beatrix	5
(129) Antigone	5
(230) Athamantis	5
(387) Aquitania	3
(402) Chloe	4
(405) Thia	3
(432) Pythia	2
Total	98
Observations of comet *b* 1902 (Perrine)	4
Observations of comet *a* 1903 (Giacobini)	6
Observations of comet *c* 1903 (Borelli)	2
Observations of occultations of stars by the moon	11
Observations of double stars	2
Observations of Nova Geminorum	2
Observations of zone stars	2
Observations of screw value, constants, etc	nights.. 12
Number of visitors received	1,175
Number of evenings devoted to visitors	56
Number of nights telescope was employed	155
Number of nights 5-inch comet seeker was employed	35

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With the exception of three asteroids, the asteroid observations were all made by Computer J. C. Hammond, to whom great praise is due for his careful and persistent labor in this field.

The comet seeker has been used by Photographer George H. Peters when his other duties gave him opportunity on favorable nights to search for new comets or for the return of old ones.

I am also indebted to Mr. C. W. Frederick and Mr. Hammond for valuable assistance in determining the constants and screw value of the instrument.

Respectfully submitted.

THEO I. KING,
Assistant Astronomer, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

THE 40-FOOT PHOTOHELIOGRAPH.

SIR: During the year ending June 30, 1903, the sun has been photographed on two hundred and two days and solar spots observed on these plates on ninety-nine days. This exhibits a considerable increase in the number of spots compared with the previous year, and indicates a rapid return toward the period of sun-spot maximum. The temperature readings and scale settings have been continued with this instrument for the measurement of focal variations and the solar photographs of best definition used for an improved determination of this curve.

Very respectfully,

GEO. H. PETERS,
Photographer, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

THE COMPUTING DIVISION.

SIR: I have the honor to submit the following report on the work of the computing division for the fiscal year ending June 30, 1903:

The observations made with the 9-inch transit circle and those made with the 6-inch transit circle are reduced to May 12, 1903, and the printer's copy is prepared from January 1, 1900, to April 22, 1903.

The observations made with the prime vertical transit instrument are reduced through 1901, except the reduction to mean place for the last year, and those made during 1902 are now being reduced.

Miscellaneous computations on the reduction of the equatorial observations have been made whenever such have been furnished by the gentlemen in charge of the two equatorials. The reductions of the observations made from 1893 to 1900 with the 9-inch and 12-inch equatorials have been checked.

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The Astronomische Gesellschaft catalogue of the stars observed at the United States Naval Observatory in the zone $-13^\circ 50'$ to $-18^\circ 10'$ is in process of formation. The stars in this zone contained in Lalande's Histoire Céleste, Bessel's Zones, Argelander's Southern Zones and Münchener Sternverzeichniss I and II have been selected and are being reduced to 1900.0 for comparison with our positions. The precessions and secular variations for 1900.0 for the catalogue are about half finished. This work is being carried on under the direction of Professor Skinner, and much of it is being done by him personally.

Some work has been done in revising the Washington Zone Observations of 1846–1849 preliminary to forming a general catalogue. A list of over 2,000 errors in the published zones has been furnished the Observatory by Prof. J. C. Kapteyn, and another list of over 500 errors by Dr. F. Ristenpart. These, together with the list of nearly 500 errors given by Prof. E. Weiss in Annalen der Kaiserlichen Königlichen Universitäts-Sternwarte in Wien (Währing), Band V, are being investigated by consulting the original records.

The copy of the original zone observations, which was sent to the late Doctor Gould and used by him in the final reductions, is still in the possession of the Observatory. A comparison of this with the original records has revealed nearly 2,000 errors. Many of these were suspected by Doctor Gould and the corresponding changes made by him as indicated in his notes, but not infrequently the error in copying has misled him in his identification of particular stars. Consequently all changes made by him as indicated in his notes are being examined.

These various pieces of work have been completed for the mural zones and about one-third completed for the transit-instrument zones. The stars in this portion of the work have to a large extent been compared with the Cordoba General Catalogue and zone corrections obtained for each zone to reduce it to the Cordoba system. The reduction of the stars of the Cordoba Catalogue to 1850.0, the epoch of the Washington zones, has been done by Professor Littell.

The 7,000 unpublished observations of 1847, 1848, 1851, and 1852 are yet to be reduced.

It is imperative that this work should be pushed to the utmost, so that it may be included in the History of the Fixed-Star Heavens, which is being prepared by Dr. Friedrich Ristenpart, of Berlin, and I wish to again strongly urge my recommendation of last year that Congress be asked to increase the computing force of the Observatory. This increase is needed not only to finish this and other work of a generation or more ago, but the last ten years' work with the two equatorials and with the prime vertical transit instrument should be published. The reductions of the observations with these instruments are well advanced, but much labor must be expended in preparing them for the press and in reading the proof.

PRINTING.

Since the last report, Volume III, Publications of the United States Naval Observatory, Second Series, has been published. Two hundred and thirty pages of Volume IV are in type, and the entire manuscript for Volume V has been sent to the printer.

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PERSONNEL.

The following members of the Observatory force have been attached to the computing division at some time during the year ending June 30, 1903:

Computer William M. Brown.
Computer John C. Hammond.
Computer Everett I. Yowell, for six months.
Computer Herbert R. Morgan.
Computer Eleanor A. Lamson.
Miscellaneous Computer Clara M. Upton, for two months.
Miscellaneous Computer Arthur B. Turner, for six weeks.
Miscellaneous Computer Lelia J. Harvie, for six weeks.
Miscellaneous Computer Etta M. Eaton, for eight months.
Miscellaneous Computer John R. Benton, for eight months.
Miscellaneous Computer Ella A. Merritt, for seven months.
Miscellaneous Computer Samuel F. Rixey, for four months.
Miscellaneous Computer Delonza T. Wilson, for five months.
Miscellaneous Computer Charles E. Yost, for two weeks.

Only a portion of the time of Mr. Brown and Mr. Hammond is spent in the computing division, the remainder being devoted to making observations.

The large number of miscellaneous computers is due to frequent changes, the regular number being 4.

Very respectfully,

W. S. EICHELBERGER,
Professor of Mathematics, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

LIBRARY.

SIR: I have the honor to submit the following report on the library for the fiscal year ending June 30, 1903:

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1902	18,378	3,975	22,353
Accessions	492	78	570
Contents July 1, 1903	18,870	4,053	22,923

Of the accessions, 357 were received as exchanges and 213 were purchased.

The following publications were distributed:

Publications, Second Series, Volumes II and III.

Meteorological observations made during the years 1891 and 1892.

Report of the Superintendent for 1902.

During the year all the serials in the rotunda were catalogued and the class marks placed upon the cards and books. The catalogue of the sections of general science, physics, chemistry, mechanics, works of reference, astronomy, geodesy, weights and measures, and mathematics is now complete. The books and pamphlets in the old record

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room are yet to be catalogued, but as most of them are of a nature which will require comparatively little research in the work, it is expected that the catalogue of the entire library will be completed within six months.

Very respectfully,

WM. D. HORIGAN,
Librarian.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DEPARTMENT OF THE NAUTICAL ALMANAC.

SIR: I have the honor to submit the following report of the operations of the Nautical Almanac Office for the fiscal year ending June 30, 1903:

PRINTING.

The following publications were received during the year from the Government Printing Office:

The American Ephemeris and Nautical Almanac for 1906, first edition, 1,000 copies.

The American Nautical Almanac for 1906, first edition, 500 copies.

The American Ephemeris and Nautical Almanac for 1903, second edition, 700 copies.

The Pacific Coaster's Nautical Almanac for 1903, first edition, 1,706 copies.

The American Nautical Almanac for 1903, second edition, 2,300 copies.

The American Ephemeris and Nautical Almanac for 1902, third edition, 100 copies.

DISTRIBUTION OF PUBLICATIONS.

During the fiscal year ended June 30, 1903, the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris	775	1,854	2,629
American Nautical Almanac	2,537	299	2,836
Atlantic and Pacific Coaster's Nautical Almanac	1,561	148	1,709
Astronomical Papers	19	1,089	1,108

The proceeds of sales, amounting to $1,749.83, have been deposited with the Treasurer of the United States to the credit of public printing.

THE AMERICAN EPHEMERIS.

The current work of this office is fully up to date, the computations for the American Ephemeris for 1907 are practically completed, and the American Nautical Almanac for 1907 is all in type. These publications will be ready for issue on January 1, 1904, the earliest date authorized by law.

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To guard more fully against errors, a much larger part of the work has been computed in duplicate than in former years.

MISCELLANEOUS.

Satisfactory progress has been made upon the work of constructing new tables of the satellites.

I beg leave to renew my recommendation that a small appropriation be made to purchase desk books and logarithmic tables to replace those worn by constant use, the contingent fund not being available for this purpose.

Attention is invited to the rearrangement of salaries as submitted in the estimates for the fiscal year ending June 30, 1905. It is believed that this schedule represents more nearly the needs of this office and will result in attracting skilled and competent men to fill the three or four vacancies that have almost continuously existed during the past two years.

Very respectfully,

WALTER S. HARSHMAN,
Professor of Mathematics, U. S. Navy,
Director Nautical Almanac.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DEPARTMENTS OF CHRONOMETERS AND TIME SERVICE, OF NAUTICAL INSTRUMENTS, AND OF STOREKEEPER.

SIR: I beg to submit the following report of the work of these three departments for the fiscal year 1902–3:

Owing to the lack of officers and assistants needed for the proper conduct of the work, it has been necessary, in order to utilize the available force to the best advantage possible, practically to merge the three departments into one. Even so, only the most pressing duties have been accomplished. To do all the work and keep the records properly would require a much larger force, and it is strongly recommended that an effort be made to secure the detail of more officers and the employment of at least two expert civilian assistants, one more clerk and stenographer, and two expert packers.

Mr. E. A. Boeger, computer, served as an assistant by detail from the computing division up to June 1, 1903, when he was appointed a clerk, class 2. His long experience as a computer and in connection with nautical instruments and the time service render him peculiarly valuable in his new position. Whatever time he has been able to spare from his regular duties has been devoted to the inspection of sextants and other nautical instruments, in which he is an expert.

Mr. E. I. Yowell, computer, was detailed from the computing division on January 14 as an assistant in the department of chronometers and time service and rendered very valuable service during the remainder of the fiscal year, being in practically complete charge of the trial of chronometers from January to June, work requiring great skill, accuracy, and attention. At the close of the year he was enabled to resume his astronomical work by the detail of Mr. H. R. Morgan, computer, in his place.

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Owing to the great increase of work with the increase of the Navy, the services of at least two expert packers are urgently needed in connection with the unpacking, handling, storage, and repacking for shipment of nautical instruments, the value of which depends largely upon their receipt in perfect condition at the station or vessel to which they are shipped. At present this important work is necessarily intrusted to laborers, who have, in addition, to attend to other laborious duties about the buildings and grounds.

THE CHRONOMETER TRIAL.

The regular annual chronometer trial began on January 2 and ended June 22, with the result that 22 new chronometers passed successfully and were accepted. The accompanying tabular statement gives complete data of the trial for all the chronometers that obtained a trial number of 25 or better. Most of the old navy standards that were entered were withdrawn for issue before the trial ended. It is very desirable, however, to have every standard chronometer put through this test after being cleaned and repaired, in order to find its relative value before issue, but to do so will require a larger supply than is now available.

It will be noted that chronometers with hairsprings of palladium as well as steel were entered in this trial, but the Bureau's specifications as now amended provide that steel shall be used until further experience with palladium has satisfied the Bureau that it is as reliable as steel. In trials at the Observatory it does very well, and gives a flatter rate-curve and better record, but there is still a question as to its permanence and durability in actual service.

The new specifications provide also for a severer test for "green" chronometers, or those not well seasoned, as shown by an accelerating rate, and require a better trial number for those accepted. Formerly a trial number of 25 was the worst accepted, but hereafter no chronometer with trial number greater than 16 will be accepted except in an emergency, and never greater than 25.

The temperature rate curves of all the chronometers that passed the trial are shown on Plate I, and Plate II gives a graphic representation of the four quantities whose sum makes the trial number. By comparing these two plates with the data of the tabular statement a clear idea can be obtained of the relative merits of the various chronometers and of the qualities in which each excels or is deficient. The effect of the palladium hairsprings is also very plainly indicated, so much so that with a little study they can readily be pointed out upon a glance at the graphic records.

TRIAL OF TORPEDO-BOAT WATCHES.

Plate III illustrates graphically the results of a comparative test of two chronometers and torpedo-boat watches aboard the destroyers *Decatur* and *Barney* from June to October, 1902, held for the express purpose of ascertaining by practical trial at sea, under service conditions, the relative merits of the two types of timekeepers for use on board of torpedo boats and destroyers. The diagrams show that the watches did nearly as well as the chronometers, and that the chronometers followed their Observatory rate-curves as well as could

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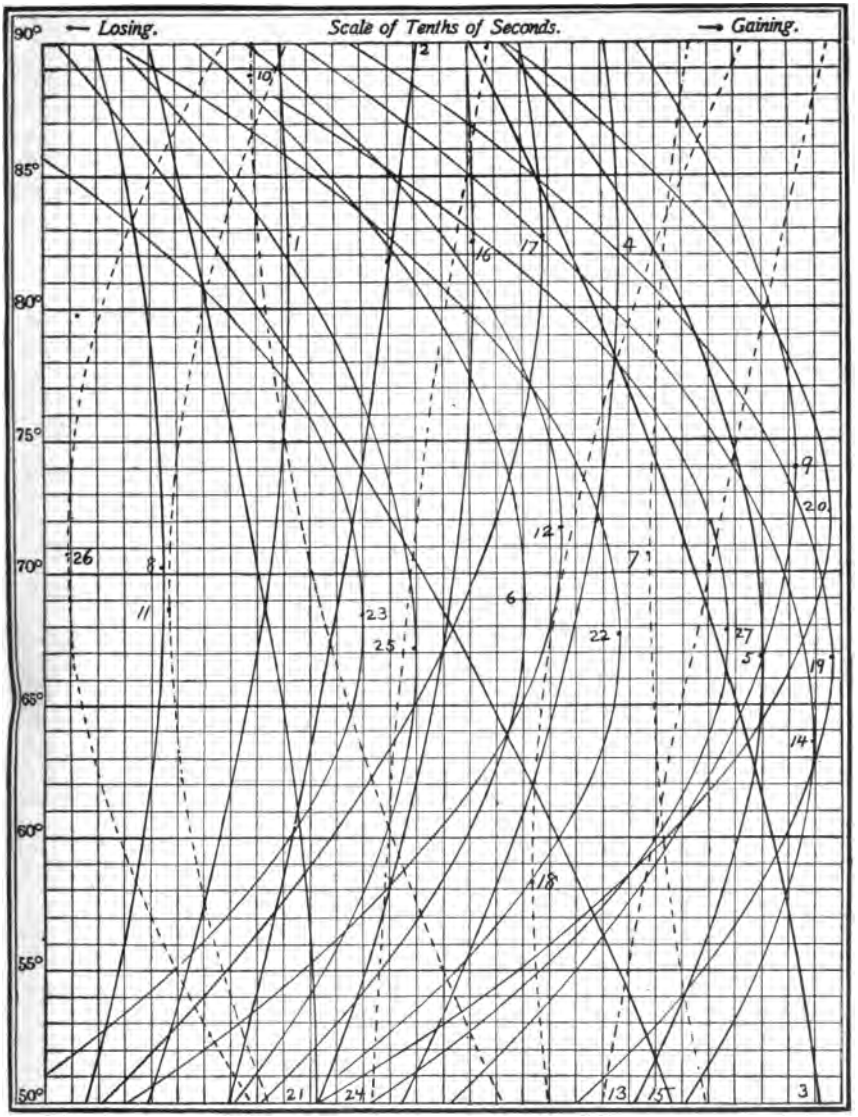
PLATE I.



TEMPERATURE RATE CURVES, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 2 TO JUNE 22, 1903.

The numbers, in order of merit, are placed at the point on the curve indicating the temperature of compensation, when that point falls within the limits of the diagram. The dotted curves indicate overcompensation.

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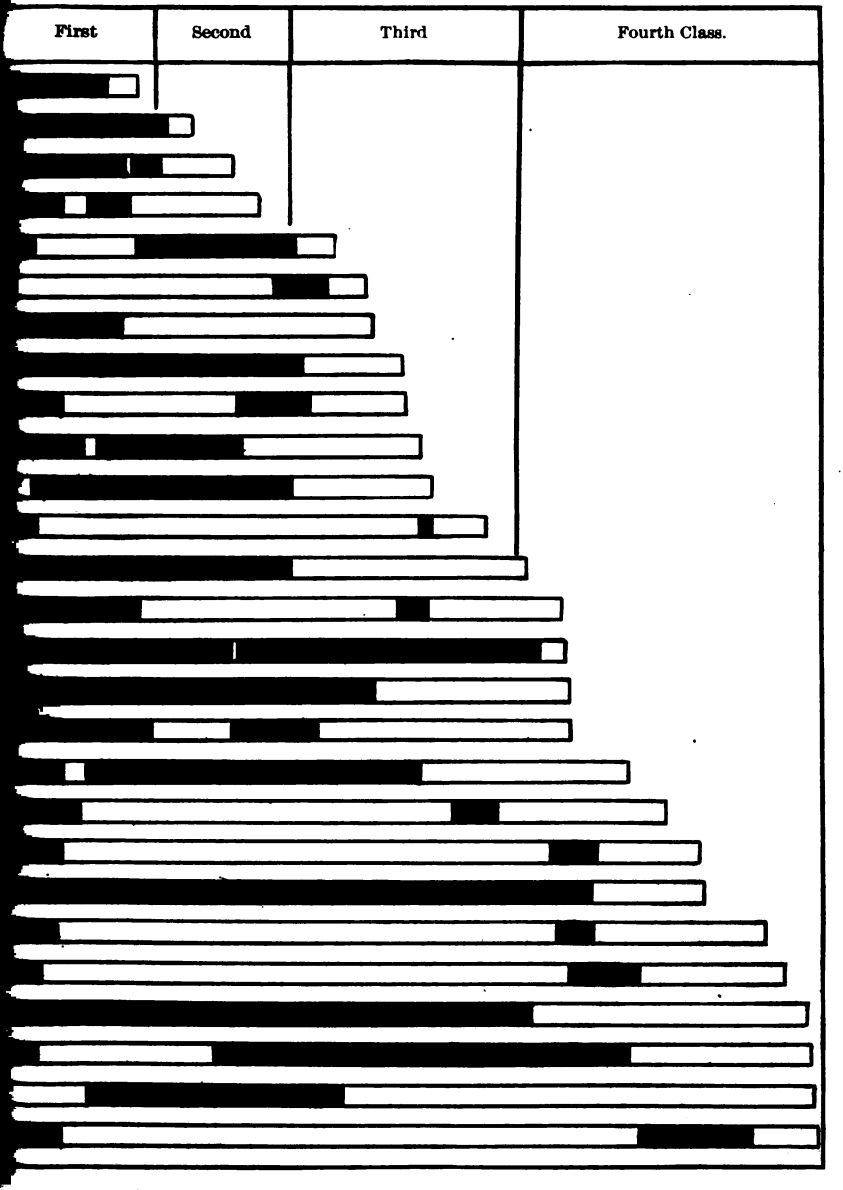

GRAPHIC REPRESENTATION OF THE FOUR QUANTITIES WHOSE SUM MAKES THE TRIAL NUMBER, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 2 TO JUNE 22, 1903.

Explanation:

Temperature of compensation. | Curvature of rate curve. | Running in the temperature room. | Running in the chronometer room.

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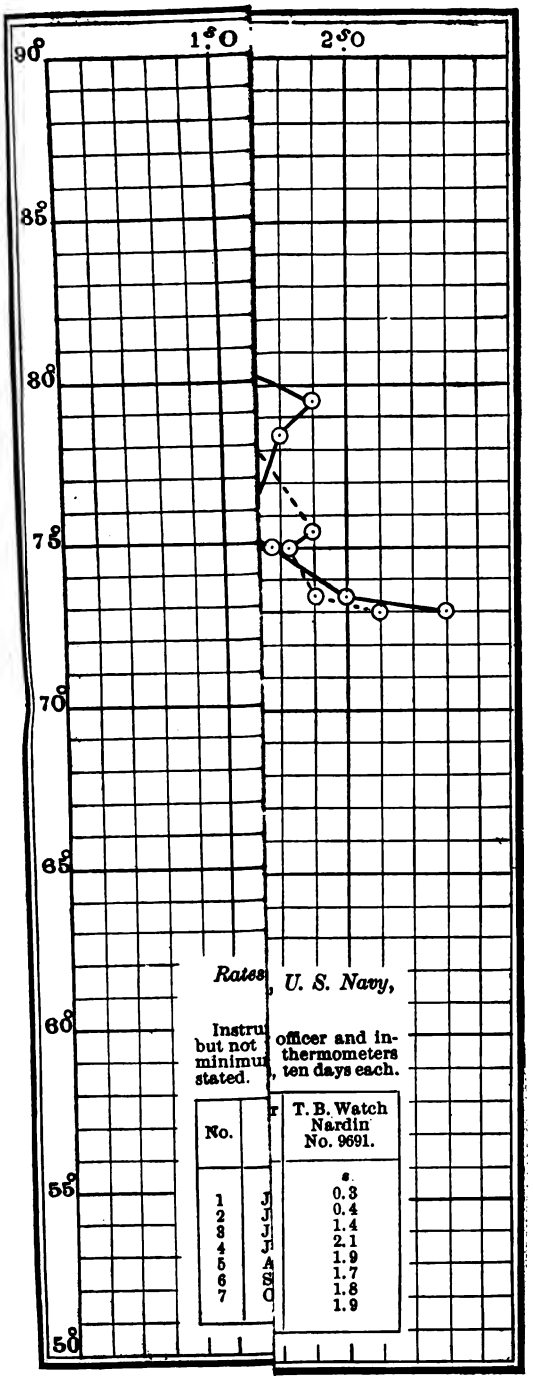
PLATE III.



Rates, *U. S. Navy*,

Instru
but not
minimu
stated.

officer and in-
thermometers
, ten days each.

No.	r	T. B. Watch Nardin No. 9691.
		s.
1	J	0.3
2	J	0.4
3	J	1.4
4	A	2.1
5	S	1.9
6	O	1.7
7		1.8
		1.9

COMPARATIVE OCTOBER, 1902.

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servatory, Washington, D. C.

ıean daily rates. (Orientation changed for polarity test, one week on E., W., S., and N.)

70.59	73.45	73.14	74.22	74.92	71.89	69.74	70.44	68.53
33.2	34.0	38.1	51.8	53.1	60.0	60.8	60.6	62.2
Apr. 20 to Apr. 27.	Apr. 27 to May 4.	May 4 to May 11.	May 11 to May 18.	May 18 to May 25.	May 25 to June 1.	June 1 to June 8.	June 8 to June 15.	June 15 to June 22.
−1.60	−1.69	−1.77	−1.71	−1.83	−1.74	−1.71	−1.80	−1.69
−0.27	−0.19	−0.17	−0.11	−0.21	−0.19	−0.14	−0.27	−0.31
0.00	−0.01	−0.11	+0.10	+0.17	+0.04	−0.11	−0.17	−0.53
−1.33	−1.44	−1.60	−1.70	−1.83	−1.67	−1.53	−1.41	−1.26
−0.70	−0.46	−0.46	−0.39	Issued to 12-inch equatorial.				
+0.26	+0.66	+0.60	+0.44	+0.56	+0.59	+0.53	+0.59	+0.60
−1.66	−1.59	−1.79	−1.77	−1.80	−1.79	−1.77	−1.86	−1.83
−1.40	−1.39	−1.47	−1.53	−1.57	−1.57	−1.61	−1.76	−1.91
+0.63	+0.80	+0.67	+0.77	+0.71	+0.90	+0.94	+1.01	+1.00
−2.04	−1.70	−1.83	−2.14	−2.43	−2.34	−2.34	−2.41	−2.46
−0.64	−0.57	−0.80	−0.89	−1.20	−0.96	−1.13	−1.09	−1.11
−2.86	−2.80	−2.84	−2.91	−3.03	−2.91	−3.00	−3.13	−3.09
−0.87	−0.87	−0.97	−1.04	−1.20	−1.30	−1.39	−1.44	−1.47
−0.10	+0.06	+0.04	+0.14	+0.09	−0.03	−0.21	−0.36	−0.73
+1.37	+1.54	+1.54	+1.59	+1.47	+1.46	+1.46	+1.37	+1.24
−1.86	−1.70	−1.81	−1.61	−1.51	−1.80	−2.04	−2.01	−2.27
+0.69	+0.53	+0.51	+0.76	+0.86	+0.81	+0.74	+0.21	+0.04
−2.56	−2.61	−2.74	−2.79	−2.86	−2.83	−2.84	−2.86	−2.93
−3.23	−3.30	−3.41	−3.37	−3.54	−3.51	−3.51	−3.57	−3.59
+1.03	+1.11	+1.06	+1.19	+1.29	+1.44	+1.31	+1.29	+1.14
+3.27	+3.10	+2.91	+3.01	+2.79	+2.87	+2.80	+2.94	+2.96
−1.20	−0.94	−1.03	−1.04	−1.19	−1.20	−1.21	−1.41	−1.49
−0.87	−0.86	−0.96	−0.97	−1.17	−1.17	−1.19	−1.30	−1.34
−2.90	−2.90	−2.86	−2.96	−2.63	−2.29	−2.20	−2.29	−2.04
+0.81	+0.74	+0.70	+0.61	+0.50	+0.66	+0.80	+0.64	+0.66
−0.56	−0.66	−0.81	−0.91	−1.03	−1.09	−1.11	−1.30	−1.44
+1.49	+1.54	+1.57	+1.49	+1.50	+1.66	+1.79	+1.66	+1.61

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be fairly expected, under such difficult conditions of active cruising in this type of vessel. The tabular statements accompanying the plate give brief but complete data of the trial.

SHIP'S CHRONOMETER RECORDS.

A new edition of the instructions and blank forms for the care and record of chronometers and watches aboard ship has been prepared and published, under your direction and with the approval of the Bureau, in which an effort has been made to state briefly and clearly the most important precautions to be taken, and to provide blank forms best adapted for their records.

THE TIME SERVICE.

The time service has continued regularly to send out daily telegraphic time signals at noon, seventy-fifth meridian time, with an average error for the year of only $0^s.15$. The widespread importance of this service is shown by the fact that it furnishes absolute standard time not only for navigators at all the principal seaports, but for the entire country except the Pacific coast, which gets a similar signal from the naval observatory at the Mare Island Yard. Moreover, all of this invaluable service is rendered to the country at no expense whatever to the Government, inasmuch as it is merely incidental to the work and the facilities required for the rating of chronometers for naval vessels.

To illustrate the wide distribution of this time signal, it is of interest to record the fact that it goes out daily over the wires of the Western Union Telegraph Company, the Postal Telegraph Company, the American Telephone and Telegraph Company, the electrical department of the District of Columbia, and the National Electric Supply Company. There are now 18 Government time-balls and some 40,000 public and private clocks corrected daily by naval time signals. The wires of the American Telephone and Telegraph Company and of the electrical department of the District of Columbia were connected during this fiscal year, and an arrangement has been made, by means of an electric sounder in the telephone room, to give the exact time by telephone at any time of day or night to anyone who calls up the Observatory.

Shortly before New Year's day a suggestion was made to the telegraph companies that they transmit the usual series of signals to end at midnight and thus announce the exact moment of the beginning of the new year. The Western Union Telegraph Company took up the matter with great interest and energy, and the series of signals was sent out at midnight, 1, 2, and 3 a. m., so that each great section of the country might get its own midnight signal direct from the Naval Observatory at Washington. The plan was carried out very successfully and elicited so much general interest that it seems advisable to repeat it every New Year's eve hereafter, and I would recommend further that an effort be made, by eliciting the cooperation of other telegraph and cable companies, to send it all over North and South America, to our most distant colonies, and perhaps all around the world, wherever telegraphs and cables extend and the necessary cooperation can be secured.

The receipt of the midnight signal was accurately timed at the Lick

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Observatory, California, and a report made to this Observatory showing that it took but 0ˢ.06 in transmission. The fact that this suggestion by the Observatory was taken up so willingly and the results greeted with such enthusiasm shows how strongly it appealed to the sentiment of the country, and if such sentiment be strong enough to enlist the cooperation of telegraph and cable companies to send similar signals around the world next New Year's eve, it seems well worthy of the slight trouble required on the part of this Observatory. Although such signals can not be transmitted automatically from land lines to long cable lines and vice versa, yet with expert manual transmission there need be little or no delay, and barring accidents the midnight signal could doubtless be sent around the world and back to the Observatory in a very few seconds of time. Such a New Year's greeting from Washington to the entire civilized world, sent out officially, but carried everywhere by public-spirited cooperation of private companies, would have a powerful, even if only sentimental, influence.

A similar experiment was tried at 9 p. m., June 15, upon the occasion of the visit of the executive board, consisting of Doctor Walcott, Admiral Bowles, General Crozier, Doctor Pinchot, and Mr. Garfield, in order to illustrate the possibilities of the time service as perfected by the Observatory in cooperation with the Western Union Telegraph Company. The signals were sent all over the United States and even beyond its limits, to Toronto, the City of Mexico, Habana, and thence to San Juan and Kingston, Jamaica. A report from the Toronto Observatory the following day stated that it was timed there and agreed within 0ˢ.20 of their standard clocks. This experiment, together with the fact that our daily noon signals are now sent regularly to Habana over the short cable from Key West, shows that time-balls can be established at all of our naval stations in the West Indies and dropped regularly by the noon signal from this Observatory.

NAUTICAL INSTRUMENTS.

The work of the departments of nautical instruments and storekeeper is best shown by the following tabular statement of instruments issued, purchased, and ordered during the fiscal year. All of them, of course, require very careful inspecton to see that they come up to the Bureau's specifications in every respect.

Stores issued, purchased, and ordered by the storekeeper's department.

Name.	Issued.	Purchased.	Ordered.
Artificial horizons	17	.....	15
Barometers:			
Aneroid	41	35	63
Mercurial	2	2	3
Binoculars:			
Day	145	75	220
Night	210	75	290
Prismatic	55	73	20
Chronographs	.....	.....	2
Chronometers:			
M. T. B. C	.....	.....	15
M. T. hack	24	12	17
M. T. standard	84	32	62
Clinometers	17	20	55
Clocks:			
Astronomical	1	1	4
Boat	52	.....	75
Deck, No. 1	68	.....	210
Deck, No. 2	77	50	70

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Stores issued, purchased, and ordered by the storekeeper's department—Continued.

Name.	Issued.	Purchased.	Ordered.
Dip circles	2	5	.....
Dividers, navigator's	54	50	75
Drawing instruments (cases)	25	20	45
Galvanometers	2	2	.....
Heliographs	4	1	1
Levels, surveyor's	3	.....	.....
Magnetometers	2	5	.....
Mercury	.....	a 150	.....
Octants	36	.....	.....
Night	2	.....	.....
Parallel rulers:			
Sigsbee, 18-inch	35	.....	55
Ordinary—			
24-inch	57	50	55
18-inch	76	80	65
15-inch	22	30	.....
Photographic outfits	3	6	3
Plane tables	5	.....	.....
Protractors:			
McCormick's navigating	5	5	.....
Three-arm	22	.....	35
Psychrometers	33	17	60
Range indicators	3	4	.....
Reading glasses, captain's	25	.....	38
Sextants:			
High-grade	26	.....	41
Squadron angle	18	.....	.....
Surveying	59	30	65
Spare glasses for, sets	4	16	.....
Splines and weights, sets	21	15	35
Spyglasses:			
High-power	46	.....	45
Low-power	62	40	80
Medium-power	35	.....	15
Officer-of-the-deck	108	60	225
Straightedges	3	.....	.....
Surveying outfits	Parts.	Parts.	.....
Tapes, steel:			
100-foot	25	16	45
300-foot	2	.....	.....
Telescopes, large	2	.....	.....
Theodolites	2	.....	.....
Thermometers:			
Air	187	30	136
Maximum and minimum	33	30	49
Water	156	50	240
Water, cases	44	.....	25
T-squares	20	.....	40
Watches:			
Comparing	41	27	45
Stop	39	20	35
Torpedo-boat	31	18	.....

a Pounds.

In addition to the large number of new instruments purchased and issued, many others are returned from ships and naval stations for repair and re-issue. This work of repair might properly and economically be done at this Observatory at least to a large extent, and I understand that it is your wish that this shall be done in future. No more central point could well be selected than this, as regards nautical instruments to be sent to and received from naval vessels and stations along our Atlantic coast by inland lines of communication, which alone can be depended upon in time of war, and the quality and character of this sort of repair work are precisely such as is required in connection with astronomical and other instruments of precision used at an observatory. It is thus both reasonable and economical to have every necessary facility provided for doing almost all of it here by experts whose services are required also for the inspection and trial of new articles of the same or similar type.

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BOARDS OF INSPECTION, TRIAL, AND SURVEY.

The regular board of inspection, of which Prof. F. B. Littell, U. S. Navy, is senior member, assisted by, according to the character of the instruments to be inspected, Assistant Astronomer T. I. King, Instrument Maker H. C. Cleve, Computer (after June 1, 1903, clerk class 2) E. A. Boeger, Photographer G. H. Peters, or Computer E. I. Yowell, has made the various inspections required from time to time of new and repaired instruments.

Other boards have met as follows:

December 16, 1902, for the survey and appraisal of damaged stock on hand: Prof. F. B. Littell, U. S. Navy, Computer E. A. Boeger, and Photographer G. H. Peters.

February 2 and March 5, 1903, for the competitive trial of prismatic binoculars: Commander C. J. Badger, U. S. Navy, Lieut. Commander E. E. Hayden, U. S. Navy, Lieut. G. W. Logan, U. S. Navy, and Prof. F. B. Littell, U. S. Navy, with Computer E. A. Boeger as recorder.

April 4, 1903, for the competitive trial of high-grade and surveying sextants: Lieut. G. W. Logan, U. S. Navy, Prof. F. B. Littell, U. S. Navy, and Computer E. A. Boeger.

May 11, 1903, for the revision of the specifications for purchase of ships' chronometers: Lieut. Commander C. C. Rogers, U. S. Navy, Lieut. Commander E. E. Hayden, U. S. Navy, and Lieut. Harry George, U. S. Navy..

ACCOUNTS OF STOREKEEPER.

The work of this department, consisting in the bookkeeping connected with chronometers and other nautical instruments, as well as with many other accounts of the Observatory, has been kept up with difficulty on account of the lack of sufficient clerical assistance, but it is gratifying to know that it has met with the approval of both the Bureau of Equipment and that of Supplies and Accounts, and that all accounts with contractors, naval stations, and vessels have been audited and approved as they have been made out and submitted. Several changes have been recommended in the specifications for the construction of various instruments and such changes have generally been approved by the Bureau of Equipment. The old stock lists for regular allowances of stock to be kept on hand at this Observatory and at the Mare Island Navy-Yard have been carefully revised, the new lists approved by yourself and the Bureau, and requisitions made to procure the necessary supplies; and, finally, the Bureau has directed that all nautical instruments turned in by ships at the various naval stations and not reserved for use and issue are to be returned to this Observatory for examination and repair.

Very respectfully,

EDWARD EVERETT HAYDEN,
Lieutenant-Commander, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1904.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

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REPORT

OF

THE SUPERINTENDENT OF THE NAVAL OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 1, 1904.

SIR: I have the honor to submit the annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1904:

PLAN OF WORK.

The plan of work was laid out at the beginning of the year on the broad ground as contemplated by the law and the instructions of the Department, and has in the main been continued as then specified in the Superintendent's order which was prepared, after mature consideration of the probabilities of the period covered by this report, by the plan of work committee, of which the Superintendent is the chairman.

PERSONNEL.

The following changes among the officers and employees have occurred since the last report:

Commander J. M. Robinson, U. S. Navy, reported for duty August 10, 1903.

T. I. King was transferred from assistant astronomer, department of astronomical observations, to piecework computer, department of the Nautical Almanac, November 24, 1903.

John C. Hammond was promoted from computer to assistant astronomer November 24, 1903.

F. E. Millis, assistant, died August 1, 1903.

H. B. Evans was promoted from assistant at $1,000 per annum to assistant at $1,200 per annum, August 12, 1903.

A. B. Turner was promoted from miscellaneous computer to computer April 28, 1904.

J. R. Benton, miscellaneous computer, was transferred to the Bureau of Standards July 1, 1903.

Arthur Snow was appointed typewriter September 21, 1903, and promoted to assistant at $1,000 per annum, June 13, 1904.

Charles N. Moore was appointed miscellaneous computer October 3, 1903.

Alice M. Gray was appointed miscellaneous computer October 22, 1903.

Jesse Pawling, jr., was appointed miscellaneous computer October 26, 1903.

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Ella A. Merritt was appointed miscellaneous computer December 28, 1903.

Florence A. Graves was appointed miscellaneous computer December 28, 1903.

Matt Frederickson was appointed miscellaneous computer March 30, 1904.

Perez Fisch was appointed miscellaneous computer April 8, 1904.

Arthur Newton was appointed piecework computer June 20, 1904.

L. A. Richards was appointed temporary miscellaneous computer January 28, 1904, and again appointed May 31, 1904.

Stephen F. McMahon, fireman, resigned July 15, 1903.

Ben Wheeler was appointed fireman October 9, 1903.

V. Muehlhaus, jr., was transferred from watchman to laborer June 1, 1904.

E. M. Rowe was transferred from laborer to watchman June 1, 1904.

H. C. Lemon, laborer, resigned April 7, 1904.

Herbert S. Murdoch was appointed laborer April 8, 1904.

C. S. Thomas, messenger boy, resigned March 13, 1904.

J. H. Nelson was appointed messenger boy April 1, 1904.

Mr. William Henderson, watchman, died May 21, 1904, after several weeks' illness. He was born in Scotland in 1846, and was for thirty-six years an employee of the Naval Observatory, first as a laborer, from 1868 to 1882, then as a watchman to the date of his death.

Mr. Henderson enlisted in the United States Army at the outbreak of the civil war, and was wounded in the battle of Fredericksburg, Va. On the expiration of his enlistment he reenlisted and served until the close of the war. His father, also a Union soldier, was killed by his side in the battle of Fort Fisher.

Mr. Henderson's services to the Naval Observatory have been of much value. For many years, in addition to his duties as a watchman, he took part in keeping the meteorological journal of the Observatory, and his faithful attention to duty has added to its prestige as one of the oldest and most complete meteorological records in the Government service. His personal character has been one for emulation, and the Observatory and his associates will feel his loss for many years.

ORGANIZATION.

Slight changes have been made in the organization of the Observatory as experience has dictated, and it stands at present as prescribed by the Regulations of the United States Naval Observatory issued by the Department January 25, 1904, as follows:

OFFICE OF THE SUPERINTENDENT.

Clerk, Thomas Harrison; stenographer, Mrs. A. P. R. Auhagen.

ASTRONOMICAL BRANCH.

A. *Department of astronomical observations.*—Division of equatorial instruments (26-inch and 12-inch equatorials): Professor of Mathematics A. N. Skinner, in charge; Assistant Astronomer J. C. Hammond, Assistant on Equatorial C. W. Frederick, Assistant in Spectroscopic Work W. W. Dinwiddie.

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Division of meridian instruments (9-inch and 6-inch transit circles): Professor of Mathematics W. S. Eichelberger, in charge; Assistant Astronomer H. L. Rice, and Computers W. M. Brown, E. I. Yowell, and H. R. Morgan.

Division of the alt-azimuth instrument: Professor of Mathematics F. B. Littell, in charge.

Division of the prime vertical transit instrument: Assistant Astronomer G. A. Hill, in charge.

The Photoheliograph: Photographer G. H. Peters, in charge.

Librarian W. D. Horigan.

Computers for the department: Computers Eleanor A. Lamson and A. B. Turner, and Miscellaneous Computers Etta M. Eaton, Alice M. Gray, Florence A. Graves, Ella A. Merritt, Perez Fisch, and Matt Frederickson.

The miscellaneous computers have been changed from time to time as candidates became available, the appropriation of $4,000 for miscellaneous computations providing for an average of four computers.

B. *Department of the Nautical Almanac.*—Professor of Mathematics Walter S. Harshman, director; Assistants H. B. Hedrick, W. Auhagen, J. Robertson, H. G. Hodgkins, J. H. Root, G. B. Merriman, W. T. Carrigan, H. B. Evans, E. D. Tillyer, and Arthur Snow, and Piecework Computers R. Buchanan, Mrs. E. B. Davis, A. Doolittle, Mrs. H. F. M. Hedrick, R. Keith, Janet McWilliam, T. I. King, and A. Newton.

NAUTICAL BRANCH.

A. *Department of nautical instruments.*—Commander J. M. Robinson, in charge; Clerk E. A. Boeger, acting assistant.

B. *Department of chronometers and time service.*—Lieut. Commander E. E. Hayden, in charge; Miscellaneous Computer C. N. Moore, acting assistant.

C. *Department of magnetism.*—Photographer G. H. Peters, temporarily in charge.

PUBLICATIONS.

During the fiscal year ending June 30, 1904, Volume V, Publications of the United States Naval Observatory, Second Series, has been issued.

As showing the contributions to astronomy in general other than that shown in governmental publications, the following list of articles made public is submitted:

In Cassier's Monthly, May, 1904: "Scientific work of the Navy," by Rear-Admiral C. M. Chester, U. S. Navy, Superintendent.

In the Proceedings of the United States Naval Institute, Vol. XXIX, No. 3: "Chronometer rates," by Lieut. Commander E. E. Hayden, U. S. Navy.

In Popular Astronomy, August–September, 1903: "A method of obtaining the focal point of a lens of long focus," by G. A. Hill.

In the Astronomische Nachrichten, Nr. 3806: "Recent observations of the declination of Groombridge 1830," by G. A. Hill.

In the Astronomical Journal, Nos. 542–543: "Observations of minor planets," by J. C. Hammond; "Observations of the satellite of Neptune," by W. W. Dinwiddie; "Observations of comet *d* 1902

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(Giacobini)," by W. W. Dinwiddie; "Observations of comet *b* 1902 (Perrine)," by C. W. Frederick.

In the Astronomical Journal, No. 545: "Elements and ephemeris of comet *c* 1903 (Borrelly)," by H. R. Morgan and Eleanor A. Lamson.

In the Astronomical Journal, No. 546: "Observations of comet *c* 1903 (Borrelly)," by T. I. King.

In the Astronomical Journal, No. 547: "Observations of minor planets," by J. C. Hammond; "Observations of Brooks's comet (1889 V)," by C. W. Frederick.

In the Astronomical Journal, No. 551: "Error in the planet (15) Eunomia in the Jahrbuch for 1905," by J. C. Hammond and W. W. Dinwiddie.

In the Astronomical Journal, No. 552: "Observations of comet and minor planets," by T. I. King; "The instrumental constants in equatorial work," by C. W. Frederick.

In the Astronomical Journal, No. 554: "Observations and circular elements of planet (1898 DW)," by W. W. Dinwiddie.

In the Astronomical Journal, No. 555: "Observations of the satellites of Uranus," by W. W. Dinwiddie.

In the Astronomical Journal, No. 556: "Observations of minor planets," by W. W. Dinwiddie; "Observations of minor planets," by C. W. Frederick.

In the Astronomical Journal, No. 558: "Observations of minor planets," by J. C. Hammond; "Observations of Brooks's comet (1889 V) = *d* 1903," by C. W. Frederick.

In the Astronomical Journal, No. 559: "Observations of the satellites of Saturn in 1903," by C. W. Frederick.

In the Astronomical Journal, No. 561: "Observations of comet *a* 1904 (Brooks)," by J. C. Hammond; "Elements and ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell.

In the Astronomical Journal, No. 562: "Observations of comet *a* 1904 (Brooks)," by J. C. Hammond; "Elements and ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell; "Observations of minor planets," by W. Walter Dinwiddie.

In the Astronomical Journal, No. 563: "Note on a probably new minor planet," from a letter of Rear-Admiral C. M. Chester; "Ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell.

In the Astronomical Journal, No. 564: "Provisional elements of the minor planet (1904 NY)," by J. C. Hammond; "Photographic positions of minor planets," by G. H. Peters.

In Harper's Weekly, December 19, 1903: "Photographing the Sun," illustrated, by George H. Peters.

In Popular Astronomy, June–July, 1904: "Elements and ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell.

The following paper was read by Professor Eichelberger before the Astronomical and Astrophysical Society of America, St. Louis meeting, 1903–4: "The pivots of the 9-inch transit circle of the United States Naval Observatory."

The following article has been communicated to the United States Naval Institute for publication: "Work of the Naval Observatory," by Rear-Admiral C. M. Chester, U. S. Navy, Superintendent.

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DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

DIVISION OF EQUATORIAL INSTRUMENTS.

From the schedule of organization it will be seen that the charge of the two equatorial instruments has been placed under one head, which permits a more harmonious distribution of the work between the observers and a more economical use of their time. Observations of an occasional character, such as those of comets, etc., can be doubled if necessary or given to the instrument that can best be spared for them or is the more suitable for the purpose. Being engaged on observations of a similar character the observers can by this arrangement be the more readily transferred from one instrument to the other in case either instrument is undergoing repairs. Professor Skinner has succeeded in getting the best results from the combination.

The 26-inch equatorial has remained in the efficient condition reported at the end of the previous year, and its utility has been considerably increased by devoting more time than formerly to the location of asteroids. The attachment of the Dallmeyer camera to the telescope has enabled Mr. Peters, the photographer of the Observatory, to establish the identity of a number of asteroids by photography, thereby saving much of the time that was given to the laborious and often ineffectual visual method. Such observations, which usually require an exposure of photographic plates of about an hour, enable the astronomer to distinguish the images of fixed stars, which show as dots, from those of members of the solar system, which are indicated by trails. The positions thus approximately determined are then given to the observers on the equatorial instruments, who with the telescope and the micrometer obtain accurate positions of these heavenly bodies. The report of Professor Skinner shows what a large contribution of asteroid observations has been made to astronomical science during the past year through the untiring efforts of Messrs. J. C. Hammond, G. H. Peters, and W. W. Dinwiddie. A quotation subsequently made from a letter received from the eminent astronomer Dr. S. C. Chandler will testify to the appreciation of their efforts by the astronomical world.

But it is not abstract science alone that is advantaged by this interesting study of asteroids, for it has a direct bearing and application to the theory of planetary motion, which forms an important part in the preparation of the Nautical Almanac for which the Observatory was designed.

Owing to the extreme faintness of many of the asteroids that have demanded investigation, it is only by means of the largest instruments that these can be observed, and indeed some of them are so excessively faint as to elude detection altogether. It was for the purpose of observing very faint objects, especially the delicate work of determining the positions of the numerous satellites of the major planets, that Congress appropriated the money for the purchase of the 26-inch equatorial, the installment of which brought to the Observatory a large portion of its prestige and to Prof. Asaph Hall, U. S. Navy (retired), his fame as the discoverer of the satellites of Mars.

As this instrument is still one of the largest equatorials in the world, it seems eminently proper that it should be employed with effect in giving to navigational astronomy the factors which enter into the

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problem of the masses of the planets and hence their motions in space. As there are but few observatories engaged in the study of asteroids, astronomers have been led to fear that some of the vast group of known minor planets—now numbering something over 500—may be lost. The perturbations in their orbits create difficulties in the solution of the problem, and unless the larger observatories retain their hold on them, as the Naval Observatory is doing, their fears may be realized.

Mr. C. W. Frederick has during the year, in addition to routine work, contributed a valuable investigation on constants of equatorials that has been well received by the astronomical people of the country.

The 12-inch equatorial is not in as good a condition as I could wish, and while it is hoped that improvements can be made, the clock mechanism, if not entirely reconstructed, is likely to continue a factor of weakness. One of the drawbacks to the output of work with this instrument is that it is used regularly by the public on one night of each week, and on additional special evenings in order to accommodate the large number of scholars in the District of Columbia who are studying astronomy. Mr. Peters has taken charge of the visitors admitted by permit during the past year, and he has by his explanations of the objects shown through the telescope made the evenings interesting and instructive.

In addition to the care of this division of the department of astronomical observations and his duties as an observer, Professor Skinner has continued to devote a large amount of time to the preparation of the catalogue of the Astronomische Gesellschaft Zone, which covers the section of the heavens between 13° 50′ and 18° 10′ south declination, a contribution which the Observatory agreed several years ago to make to the material for a general catalogue of the stars to the ninth magnitude.

DIVISION OF MERIDIAN INSTRUMENTS.

The division of meridian instruments has remained in the charge of Professor Eichelberger, and his administration is commended.

In addition to the repairs on the 9-inch transit circle, which have put the instrument in first-class condition, a south meridian mark has been mounted. This, in conjunction with the north mark, affords a determination of the collimation independent of the collimators and greater accuracy in the determinations of the azimuth.

The work of this division includes the determination of the right ascension and declination of the sun, moon, and planets, the stars of Newcomb's Suggested List of Fundamental Stars, and others that are required for Nautical Almanac purposes.

In laying out the work of this division for the year it became apparent that while two good instruments were available—the 6-inch and 9-inch transit circles—better results would accrue by concentrating the limited number of observers on the 9-inch transit circle, which was just in from the repair shop, where it had been for nearly two years, and leaving the 6-inch transit circle for such incidental work as might be called for. The great advantage of concentrating the observers upon one instrument is the saving of the time that would be necessary for the determination of a second set of constants, which time can be devoted to obtaining additional observations.

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The excellent record of this division, having nearly 12,000 observations to its credit, a larger number than was ever obtained before at the Observatory in any one year, even when both instruments were in use, shows the wisdom of the arrangement considering the number of observers available. If a suitable force is given the Observatory to complete the reductions of the observations made, another fact, that the arrangement is conducive to the saving of time in making the reductions, will also be demonstrated.

The clock system of the Observatory, upon which all our right ascensions depend and upon which so much time has heretofore been expended, has during the year been given serious attention. One of my first duties as Superintendent of the Observatory was to purchase from Clemens Riefler, of Germany, one of his best clocks. These clocks are the exponent of the most advanced thought and inventions of the age, but they must be manipulated with intelligence and painstaking care, or they become valueless. After this clock was set up and adjusted in the clock vault Professor Eichelberger and Mr. Cleve, the instrument maker, gave it their constant attention. One difficulty after another was met and overcome, but there are apparently inherent faults in the mechanism of the electric winding which only the makers can remedy, and it has been returned to Riefler for correction.

Soon after the Observatory clock was purchased the Bureau of Equipment purchased four other clocks of a similar character from the same maker. One was sent direct to the naval station at Cavite, Philippine Islands, and another has been shipped to Sitka, Alaska. By the Bureau's direction the other two, one intended for Tutuila and one for Guam, were received at the Naval Observatory for test and adjustment. The Guam clock has been set up in the clock vault and the Tutuila clock in the clock room. Thus the Observatory has been provided for the time being with three of the most modern clocks known to the profession. These have all contributed to our knowledge of clock mechanism, and Professor Eichelberger's persistent efforts to get them into the most efficient condition is most creditable.

The work formerly done in a computing division is now carried on under the general supervision of the committee on editing and printing, with the head of the division of meridian instruments as member and secretary. This plan is naturally suggested, as the amount of reductions in the division of meridian instruments greatly exceeds that in all the other divisions, while it brings into cooperation all the heads of divisions in arranging the work in harmony with the various interests.

A demand has long existed for a catalogue from the Washington Zone observations made at this Observatory in the early years of its existence, and this work has been taken up from time to time, only to be dropped in order that the small force might keep up with the current work. A moral obligation rests on the Observatory to publish this data in a completed form for the benefit of science, and it is hoped that it may not again be necessary to entirely drop it from the routine work of the Observatory until its final completion.

The publications of the Observatory have followed each other in rapid succession since the beginning of the century. During the few years immediately preceding 1900, when no Observatory volumes were issued from the press, the entire time of the computing force was devoted to the reduction of observations. The use of a portion

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of the computing force in preparing copy for the printer and in reading the proof incident to the issue of the Observatory volumes, as is now necessary, lessens the amount of computing done. Further, the reduction of a single month's observations of the past year could not be completed by the existing force in several months' time. In consequence of the necessities due to printing and of the large number of observations accumulating the current work is falling rapidly into arrears, and hence I urgently request that the estimate of $10,000 for miscellaneous computation may receive favorable consideration.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

In December, 1903, I decided upon the reorganization of the department of astronomical observations, as noted heretofore. It seemed that the three professors of mathematics stationed at the Observatory and the one assistant astronomer who had for several years been in charge of instruments were the natural heads of divisions. Mr. G. A. Hill, assistant astronomer, was at the time not only in charge of both the 5-inch steel alt-azimuth instrument and the prime vertical instrument, but was the sole observer on these instruments. He had completed nearly eleven years' observations of the nineteen that form the period of the revolution of the moon's node, and it seemed that this important series of observations, rarely if ever so continuously carried on by one person, should receive his undivided attention. I therefore subdivided his division, and placed the charge of the alt-azimuth instrument in the hands of Professor of Mathematics F. B. Littell.

From July 1 to December 1, 1903, Mr. Hill continued his vertical circle observations of stars of a list selected from those recommended by the Paris Conference of 1896 for publication in the nautical almanacs of the United States, Great Britain, France, and Germany, and published in the Astronomical Papers of the American Ephemeris and Nautical Almanac, Volume VIII, Part II, Newcomb's Suggested List of Fundamental Stars. I would add that Mr. Hill was loath to give up the charge of the alt-azimuth instrument, in which he had taken so much pride and which he had most energetically and efficiently handled for nearly six years for the best interest of the Observatory.

The work laid out for the instrument under the new management was to take up the observation of all the stars of Newcomb's Suggested List of Fundamental Stars, culminating here at zenith distances less than 75°.

As always in the case of a change of observers on a telescope, a study of the instrument had to take place. This work was carried on as expeditiously as possible, and soon active operations began, although the observations made since the reorganization have not been sufficiently reduced to determine the quality of the results. That the hard and intelligent work of Professor Littell with this instrument will bear fruit well worthy of the high character maintained by this Observatory's records can not be doubted.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

In the division of the prime vertical instrument, Mr. Hill has continued his series of observations for the purpose of obtaining the variation of latitude and corrections to the constants of aberration and

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nutation. He has completed nearly eleven years of the nineteen that form the period of the revolution of the moon's node.

Mr. Hill has finished the list of 390 stars which he has been observing on the prime vertical. Of these, 26 are contained in the Suggested List of Fundamental Stars, prepared in the Nautical Almanac Office, 9 are contained in the list being observed at the International Latitude Stations under the direction of the German geodetic service for the purpose of obtaining the variation of latitude, and 15 are contained in the lists used by Professor Doolittle, of the University of Pennsylvania, Philadelphia, in his latitude determinations. These recent observations will afford excellent material for improving the present knowledge of the star places and their proper motions.

THE PHOTOHELIOGRAPH.

Mr. G. H. Peters, photographer, in charge of the photoheliograph, has continued to photograph the surface of the sun each clear day of the year, to obtain a record of the spots which appear on its disk. The continuous record made by him of several years' duration not only affords a study of the solar surface upon which scientists have devoted much thought, but since such changes as are observed there are connected very intimately with the changes which take place in the magnetism of the earth, which in turn has a direct influence upon the compasses which guide our ships safely from port to port, the importance of this photographic work to the Navy itself is apparent. Unfortunately, owing to the close proximity of an electric-car line the work of the magnetic observatory that was connected with this station for many years was discontinued, but this has not lessened the necessity for continuing the important work of solar photography.

LIBRARY.

The library has continued in charge of the efficient librarian, William D. Horigan.

The value of this library as a standard for reference on scientific subjects is recognized not only by other departments of the Government, but by institutions of learning situated in Washington and elsewhere in the United States.

Soon radical changes will have to be made in its quarters to meet growing necessities, and to provide suitable accommodations for some of the most valuable publications belonging to the Government which are among its contents.

DEPARTMENT OF THE NAUTICAL ALMANAC.

The efficient work of the Nautical Almanac department has been maintained, and its force has been able to keep the current work up to date. About one-half of the American Ephemeris for 1908, and the same amount of the American Nautical Almanac for 1908 is in type, thus insuring their issue on January 1, 1905, the earliest date authorized by law.

Attention is called to the report of the Director of the Nautical Almanac recommending legislation governing the issue of a sufficient number of publications to supply the needs of the Navy Department, which is approved.

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DEPARTMENT OF NAUTICAL INSTRUMENTS.

As shown in the report of its head, the work of this department has greatly increased and is increasing. As there was no naval officer available for assignment as the head of this department up to August 10, 1903, from the time of the Spanish war, the duties of this department were carried on in connection with those of the department of chronometers and time service. The work, therefore, mainly fell upon a force of one computer from the department of astronomical observation and a clerk detailed from the Superintendent's office to assist in the preparation of specifications, estimates, vouchers, bills of lading, reports, etc., incidental to the purchase, inspection, care, and issue of about $100,000 worth of the most delicate nautical instruments.

When Commander Robinson, in the early part of the year, was ordered to duty at the Naval Observatory he was assigned to the vacant position of head of this department; and Mr. E. A. Boeger, who had been taken from the computing division to carry on the work of the department, having in the meantime been appointed a clerk in the Superintendent's office to fill a vacancy, was continued as the sole civil employee in the department, which duty he has very energetically and satisfactorily performed. Mr. Boeger has become by experience an expert in testing nautical instruments, and it is desirable to retain his services in this department.

To carry on this important work I have provided in the annual estimates for an assistant in this department at a salary of $1,600 per annum, and respectfully urge that the position and salary may be provided for. It should be understood that duties in this department include not only the care and inspection of valuable instruments, but also all the labor usually performed by a staff of clerks at navy-yards in the purchase and inspection of the same and their issue to the fleet. A comparison of our force with that of any station which handles a like amount of material will show how inadequate is the force here, and when the character of the supplies is taken into consideration the proportions show markedly in favor of an increase for this station.

About 250 sextants alone, which have been inspected at the Observatory for the Navy during the past year, have required the continuous services of one person for about seventy-five days, and this amount of time, lengthened out by the various incidental calls on the department, has acted to lock up money which contractors have a right to expect thirty days after the delivery of supplies.

Recently the Treasury Department has made rulings regarding the payment for transportation of supplies which have added materially to the clerical work incidental to their issue to the fleet, and the Department must expect delays in executing shipment orders, or furnish the means of complying with them.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

Particular attention is called to the report of the head of the department of chronometers and time service. The importance of this department of the Naval Observatory can not be overestimated. This Observatory, like its prototype, the Royal Observatory of England, was founded for the purpose of establishing the position of ships at sea, and hence the inspection, purchase, and rating of chronometers,

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by means of which the longitude is obtained, have always been essential features of the work of both observatories. While the longitude may be obtained approximately without the appliances furnished by this department, yet navigation has become so dependent upon the use of chronometers that it would be a suicidal policy not to fit out ships with those which may be called standard in every respect.

The demands of our increased fleet have added quite as much proportionately to the work of this department as to that of any other department in the Navy. Not only has the number of chronometers been greatly increased, but the means of determining their accuracy here and the determination of their errors in service have so developed as fully to double the demand for personal attention. Repeatedly reports are received here relating to chronometers on board of the different ships of the Navy, and of special investigations that are being carried on in actual service, but under the supervision of this office, that require to be studied and carefully recorded to form a complete history of each chronometer in the Navy. For instance, as the Bureau has been informed, the question of what is the best material to be used in the construction of the spiral hairsprings of chronometers is a very important one; whether to use steel in their manufacture, as has been done for a long series of years, or to take up palladium or some alloy that is claimed to be an improved combination of metals, must be decided very soon. The tests applied to chronometers at this Observatory show that palladium is less susceptible to the variations of temperature, which, as our ships go to all parts of the world, is an important factor in their care; but whether the material will retain its spring as long as steel is yet to be determined.

American chronometer makers look to this department for scientific experiments in this and kindred subjects to guide them in their manufacture, and a conclusion can be reached only after many years of investigation; hence the care that must be taken to keep the records complete and to follow up the experiments accurately and persistently for many years. The force allowed to carry on this work is entirely inadequate. The test to which our chronometers, amounting to $40,000 or $50,000 worth, are subjected for a period of six months each year is a most absorbing occupation. The head of the department, who has many other matters of importance to attend to besides chronometers, is provided with the services of only one assistant. One man can not, as a rule, owing to the demands of the astronomical department, be kept on this duty longer than six months. He therefore hardly becomes familiar with his duties before he is withdrawn.

When it is considered that so delicate are the chronometers supplied the Navy that the Government sends an experienced officer to carry a few of them, valued say at $2,000 or $3,000, from point to point when necessary, at an annual expense for travel running up into many hundreds of dollars, it does not seem consistent to have the $40,000 or $50,000 worth of these instruments liable to be left in the hands of an inexperienced assistant, as the present system necessitates.

I have provided in the annual estimates for the salary of one assistant for this department at $1,600, which is the very least force that can properly do the work. If approved, the person selected for this position should be a graduate from some horological institution, who could make slight repairs to watches and clocks, as well as carry on

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the necessary computations relating to chronometers. When it is considered that the traveling expenses alone of officers who must carry these delicate and expensive chronometers from point to point will run up into hundreds of dollars, it does not seem extravagant to recommend the services of one assistant at the moderate salary of $1,600 to care for them at the Observatory, especially when it is remembered that such allowance will restore to his regular duties the computer now detailed to the position at the expense of the astronomical work.

I can not too strongly express my appreciation of the great amount and excellent character of work that has been done by Lieut. Commander E. E. Hayden, as his report shows, and I have felt guilty of neglect of duty in being obliged to furnish him with so small a force for meeting this important part of the demands of the fleet. This duty alone, which calls for the continuous work of four or five persons in institutions engaged in similar work to that carried on in this department, has, unlike them, another branch, which calls for a large share of the chief's attention. This is the time service of the United States, which is practically controlled by the Observatory, and which calls for incessant care.

The adoption of standard time with, all its manifold advantages, is the outgrowth of efforts put forth and developed by naval officers on duty at the Naval Observatory. When the great possibilities of this system became apparent, the railroad companies of the country, appreciating its necessity to themselves, took up the matter and, working in harmony with this Observatory, produced the general plan which has gradually been followed by the leading countries of the globe, and which all interested parties agree should be made universal.

The scheme for sending a greeting and announcement on the exact instant of the birth of the New Year to all parts of our country, as referred to in my last annual report, was so successful that it was repeated at the beginning of 1904, when it was extended to reach as far as England, Australia, Alaska, and Argentina, thus covering nearly three-fourths of the civilized world. Indeed, but for the demands brought upon the great eastern telegraph systems by the disturbances in China, it is believed that these signals would have extended around the world, and such a result seems more than possible for the beginning of 1905. This scheme, proposed by Lieutenant-Commander Hayden, has been received, as his report shows, with marked interest both at home and abroad. It all tends toward the general appreciation and adoption of a universal time system. As this country, more than any other, has helped to make international in character the adoption of Greenwich as the initial meridian of this system, so it would seem that our people, as the recognized leaders in the establishment of standard time, should endeavor to make it universal. The effort to do so will be maintained and the prospect of consummation is very good.

I take advantage of this opportunity to express my appreciation of the hearty voluntary cooperation of the various telegraph and cable companies in working so energetically and successfully with this Observatory in transmitting these special time signals over their lines, notably the great Western Union and Postal Telegraph companies and their connections. Perhaps with the development of wireless telegraphy it is not too much to expect that the day will come when not only every land station but every ship at sea will receive the daily noon

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signal from our standard clock, in which event practically all of the uncertainties of longitude determinations at sea will vanish. When that day comes (and it seems now to be entirely practicable) this clock may be heard in every land and on every ocean of the globe, and be available daily both for standard time and navigation everywhere.

On the recommendation of the Superintendent, with the favorable indorsement of Rear-Admiral W. C. Wise, commander in chief of the U. S. Training Squadron, and others, the Department, on March 24, 1904, established at Fort Monroe, Va., an office for the delivery of standard time from this Observatory to the fleet, which is often assembled in the waters of Hampton Roads, as well as to the large army station located there. With the cordial cooperation of the commanding officer of Fort Monroe, which met with the approval of the Army and Navy General Board and the Secretaries of the two Departments, a portion of a building on the Government wharf connected with the station was set apart for an office, and Lieut. Houston Eldredge, U. S. Navy (retired), was, by direction of the Navy Department, assigned to its charge.

I have already set forth in a report to the Bureau the desirability of thus giving direct from Washington the means for rating chronometers to the large number of naval vessels which in peace times frequently congregate there, and which as a station in war times they are likely to use as a base from which to operate against the enemy. But I wish to call attention to the valuable assistance which the Western Union Telegraph Company has given the service in establishing this office by running its lines without expense to the Government from its main office at the Fort Monroe army post—a considerable distance—to this office, and therein locating a sounder for the noon time signals sent out from this Observatory.

I forego forecasting the benefits which must accrue to the Army and Navy by the establishment of this office, but I am sure that Lieutenant Eldredge will so arrange its operations as to receive commendation from both services, as well as from the large mercantile fleet which will use the plant. With the removal of the old Hygeia Hotel the time-ball formerly established there was discontinued, and it is hoped soon to reestablish it at this new time-signal station, for the benefit of the Navy and commerce, to both of which it is essential.

DEPARTMENT OF MAGNETISM.

The Government has an important magnetic station near Washington connected with the United States Coast and Geodetic Survey, and it is the desire of myself as the Superintendent of the Naval Observatory to make such exchanges of records as will best subserve the interests of the General Government; but from outside of the United States, in the broad field covered by the ships of the American Navy and elsewhere, by exchange of data, we are accumulating records which will be valuable for a study of the magnetism of the entire earth. Not only are our large ships equipped with magnetic instruments for securing observations of terrestrial magnetism in localities which they visit, but recently, by authority of the Department, the valuable magnetic instruments that could no longer be used here were transferred to Tutuila, Samoa, for use in connection with the astronomical observatory which is in process of construction there. The magnetic station

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at Tutuila will cover a field from which there is as yet a dearth of information bearing on the subject, and will thus supply data of great practical and scientific importance. These changes have lessened the importance of the magnetic department, which by the regulations is a part of this Observatory, and to which in former years two naval officers were generally detailed for duty; but as it is essential to assimilate the records which come in from our own country with those received from abroad, I have detailed Mr. Peters, the photographer, to its charge temporarily.

In this connection I desire to call attention to the desirability of having the compass office, now located in the Navy Department building, associated with and made a part of this Observatory. The fact that all other navigational instruments, except compasses, issued to the vessels of the Navy come from this Observatory would logically point to the conclusion that this one instrument should also come from the same source, even if there were no other reasons for it. But as a direct connection has been shown to exist between sun-spot phenomena and terrestrial magnetism, which governs both the theoretical study and practical manipulation of compasses, it seems appropriate that the theory and practical knowledge relating to these important navigational instruments should go hand in hand. I would therefore recommend that the compass office be removed to and become the department of magnetism in the Naval Observatory. Other recommendations in this report covering the purchase of the Industrial Home School property, if approved, would make this scheme feasible as far as quarters are concerned, or in any event temporary accommodations could be arranged to meet the necessities of the combination without materially affecting the other work of the Observatory, and at the same time make available for other use the quarters now occupied by the compass office in the overcrowded Department building. Many other advantages would follow from such consolidation, such as abundance of space for out-of-door observations, the presence of a skilled instrument maker to make slight repairs, the consolidation of shipments to vessels, and the association of experts working along similar lines.

SUMMARY OF WORK.

Instruments—	Observations.
26-inch and 12-inch equatorials	1,377
9-inch and 6-inch transit circles	11,754
Alt-azimuth	1,495
Prime vertical	314
South transit (time service)	137
Photoheliograph	210
Total	15,287

	Number.
Chronometers, clocks, and watches inspected and rated	880
Nautical instruments inspected	4,245
Visitors admitted by permit	1,087

BRANCH OBSERVATORY AT TUTUILA, SAMOA.

The establishment of a branch astronomical observatory at Tutuila, as outlined in my last annual report, has continued to receive my attention during the year. Early in the fiscal year the commandant at Tutuila, Commander Underwood, ordered a board to recommend a

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site suitable for an astronomical observatory and magnetic house. The board, after careful consideration of the subject, recommended the purchase of land on Blunts Point, on the west side of the entrance to the harbor, as giving practically a north and south horizon free from obstructions. The approximate area recommended to be purchased is between 8 and 9 acres.

On further consideration of the matter by a board ordered by me to draw up detailed plans, the Bureau approved the scheme and the Department authorized the purchase of the land and the construction of the observatory.

Mr. C. W. Frederick, assistant on equatorial (who, with Asst. Astronomer G. A. Hill as senior member of the board and Asst. Astronomer J. C. Hammond as the other member, drew up complete plans for the transit circle house, the dwelling for the observers, including a clock room in which the temperature can be controlled, and partial plans for the magnetic house), was on my recommendation ordered to proceed to Samoa and report to the commandant of the naval station at Tutuila, to take charge of the observatory. Mr. Gustave Harrison, who for several years has acted as janitor of the great equatorial building and as general assistant in the care of the 26-inch equatorial, and who is a practical photographer of considerable experience, was at the same time appointed care taker of the observatory, as well as to act as assistant in magnetic and other work which is to be undertaken there.

Preparations are being made here to carry out the instructions of the Department.

MACHINE SHOP.

The machine shop established on the premises last year with old material from navy-yards, as mentioned in my last annual report, has already demonstrated its value.

Mr. W. W. Dinwiddie, assistant in spectroscopic work, has done, with little or no aid, some work on eclipse apparatus and made small repairs to other instruments of the Observatory. He has also completely overhauled the old Clark mounting of the 26-inch equatorial, which is being set up for carrying the tube of the old 9.6-inch equatorial, all of which material had been discarded. Two Dallmeyer cameras, each of 40-inch focus and 6-inch aperture, will also be carried by this mounting, and the 9.6-inch equatorial be used as a guiding telescope for photographing asteroids. This arrangement will permit an expansion of the asteroid work and allow the 26-inch equatorial to be used entirely for micrometric purposes.

Mr. Dinwiddie spent a large portion of his annual leave in visiting some of the important observatories of the country, spending a week at the Yerkes Observatory, bringing back to the Naval Observatory much useful data which have been utilized to the advantage of its plant.

I have also to mention that Mr. G. H. Peters, the photographer of the Observatory, likewise gave up practically all of his annual leave in the zealous search after information from other observatories which would benefit our work.

GROUNDS AND ROADS.

There still remains to be acquired to complete the plot of land lying within a radius of 1,000 feet of the Observatory's clock room, as contemplated by the joint resolution of Congress approved August 1, 1894,

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the tract belonging to Mr. Philip Young and the tract belonging to the Normanstone estate; also the property belonging to the District of Columbia, containing 6.764 acres, occupied by the Industrial Home School.

The question of title to the first two pieces of property remains in the District courts, to which it was referred on appeal from the decision of a board which condemned the land for Government use.

Referring to the Industrial Home School tract, the Department has stated in its letter to the District Commissioners of April 10, 1902, that "an agreement as to the equitable reimbursement of the Board (of Charities) for buildings situated within the Observatory Circle may be reached, which would enable the District Commissioners and the Department to unite in presenting to the consideration of Congress a measure that will fully protect the interests of the Observatory and the Industrial Home."

With a view to reaching such an agreement the Department appointed the Superintendent of the Naval Observatory, and the District Commissioners appointed Mr. George S. Wilson, secretary of the Board of Charities, to consider the matter. With Mr. Wilson I have endeavored to act as would a board of appraisers if condemnation proceedings should be instituted against this property, as recommended in the Superintendent's annual report of June 30, 1902, and which action it is not practicable to take without legislation.

The Department having agreed with the Commissioners as to the price of the land in question, viz, $74,404, which is at the rate of $11,000 per acre for the 6.764 acres of the Industrial Home School lands within the circle, as stated in the letter to which reference was made, it only remained for us to reach a conclusion as to the price of the buildings.

It is clear that any board of appraisers which might be established if condemnation proceedings were inaugurated through the courts would, as is usual in such cases, allow the District authorities not only for the value of the buildings located on the land which the Government proposes to take, but would award damages for such buildings as might be destroyed or otherwise rendered valueless by the transaction. Having reached an agreement as to the equitable reimbursement to the Board of Charities for the buildings, I submitted a report to the Department, and Mr. Wilson one of like purport to the Commissioners, embodying our conclusions. The arrangement submitted seemed the more desirable, owing to the fact that I saw and presented a scheme by which the Government could utilize, for a time at least, the buildings against which damages would fall.

The Department in considering my report ordered a board, composed of Rear-Admiral C. M. Chester, U. S. Navy, Civil Engineer R. E. Peary, U. S. Navy, and Lieut. Commander W. L. Burdick, U. S. Navy, to examine and report upon the same. The board states in its report that:

We are of the opinion that the buildings, viz: the main building, the west building. and what is known as the schoolroom, which are all connected and form one large structure, can be made adaptable for the requirements of the Navy Department or some of the subordinate bureaus or offices; that the shops, boiler house, coal and spring houses and barn could be utilized as accessories to such offices. The cottage might be utilized for quarters for officers stationed here or could be turned into additional offices. The greenhouses would be of little practical value for Governmental purposes, but should necessarily be considered in the question of compen-

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sation, as under any condemnation proceedings that might be instituted, if the parties at interest should be forced to that method of procedure, damages would unquestionably be allowed to at least the amount given. * * *

The only equitable settlement of the matter we believe to lie in the plan outlined in the report of the Superintendent of the Naval Observatory, dated December 9, 1903, for the Government to purchase all the buildings pertaining to the Industrial Home School, except the new schoolhouse which is isolated from the other buildings, and to secure, in addition to the purchase as contemplated in the joint resolution of Congress, approved August 1, 1894, a lease of such land outside the circle as may be necessary for the proper utilization of the buildings located thereon. This land will eventually be used for streets and is therefore not saleable by the District. This plan would enable the Government to make use of the two buildings located on such land, viz: the west building and the cottage; also a small portion of what is called the main building (shown on the plan appended, marked "B"), for a sufficient length of time (probably fifteen or twenty years at least) to partially compensate for their cost.

We therefore recommend that the Government acquire the property covered by the joint resolution of Congress approved August 1, 1894, on the basis of $110,000 for the buildings and $74,404 for the land, a total of $184,404; and to secure a lease at a nominal rental for such additional land outside the circle as may be necessary.

This report is referred to herein, as the Department's action on it was to direct as follows, on April 23, 1904:

In view of the advanced period of the Congressional session, it is believed that no action can be advantageously taken at this time upon the recommendation made by the Board in the within report. The matter will, however, be taken up and considered at the proper time in connection with such recommendations as may be made in the annual reports for this year or otherwise by the Bureau.

Congress having then decided by its joint resolution of August 1, 1894, that the Observatory grounds should consist of a plot bounded by a circle of 1,000 feet radius, the Department having come to an agreement with the District authorities as to the value of the land belonging to them within this boundary, and having ordered a board to consider "as to the equitable reimbursement of the Board (of Charities) for the buildings situated in the Observatory Circle," and the Board having recommended that the Government acquire the property covered by the Congressional resolution of August 1, 1894, and that it secure a lease of such additional land outside the circle as may be necessary, I respectfully urge that action be taken in time to present the matter to the next session of Congress. A definite scheme for carrying to execution the will of Congress, as expressed by its resolution referred to above, follows herewith.

Mr. George S. Wilson, representing the Commissioners of the District of Columbia, and myself, representing the Navy Department, acting under the instructions of our respective Departments, have agreed to submit the following plan in accordance with those instructions, viz:

The Navy Department (*a*) to acquire by purchase legal title from the Commissioners of the District of Columbia to the plot of ground that is situated within the Naval Observatory Circle, amounting to 6.764 acres, more or less, being parts of lands generally known as the Industrial Home School property, for the sum of $74,404. (*b*) To secure a lease from the District Commissioners at a nominal rental until such time as the land or the most of it may be required for street purposes, that other portion of the said Home School property described as follows: "Begin on the Observatory Circle where it intersects the north boundary of the Industrial Home School grounds; thence south 79 degrees 28 minutes west along said boundary a distance of 285 feet; thence south 275 feet; thence east about 160 feet to

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said Observatory Circle; thence northeasterly along said Observatory Circle to place of beginning;" about 1.40 acres. (*c*) To acquire by purchase title to all buildings on the aforesaid pieces of property at a cost of $110,000; a total of $184,404.

A plan marked "A" is herewith appended showing the status of land lying within the Observatory Circle and also giving the boundaries of the section which should be leased from the District Government to carry out the recommendation of the board which was ordered by the Department to consider the subject.

In the estimates of appropriations required for the service of the Naval Observatory for the fiscal year ending June 30, 1905, there was submitted an item for the building of two houses as observers' quarters. The necessity for the construction of these buildings has been noted in the annual reports of the superintendent for several preceding years and the necessity has not lessened. But as the question of the Government's acquirement of the property belonging to the District of Columbia, known as the Industrial Home School, has reached such a state as to warrant a hope that by the speedy transfer of the buildings on that property to this station the demand for quarters may be at least partially met, the estimates for the coming year will not contain this item.

One of the acts of the Board of Visitors for 1901 was to report that "there is urgently needed residences for those who are regularly engaged in late night observations." For efficient work in observing the heavenly bodies those engaged in it must be near at hand or they will lose a great many of the comparatively few favorable moments available in this region for astronomical investigations. Particularly at this Observatory the distance of our instruments from habitations where the staff must live—in Georgetown or elsewhere—makes it exceedingly trying for the observers to go to their duty at all times of the night, and when the indications are unfavorable and they naturally go to their homes they must rely on irresponsible persons to awaken them when a change for the better occurs, with the chances in favor of their not getting to their stations. The result is that many observing nights are lost to the Observatory.

Suitable quarters are provided on the grounds for only two of the observers. Four others are temporarily provided with sleeping quarters in an old building which has been fitted up for them as best it could be done, but which affords them a less degree of comfort than would ordinarily be found in barracks for troops. The remainder are obliged either to sleep in their offices or off the grounds. This acts as a hardship on the members of the staff and results in less efficient service than should be rendered at an institution of this character.

If the scheme for the purchase of the Industrial Home School property is carried through, the buildings which it is proposed to buy and which in any event must be paid for will for the time being at least relieve the demand for new quarters for the major part of the staff.

The comparatively small amount of extra compensation asked for to reimburse the District of Columbia for their buildings lying outside the Observatory Circle will thus in more ways than one lessen the necessity for increased appropriations which the natural growth of this as well as all other Departments of the Government must entail.

As was predicted in the Superintendent's annual report for 1902, the appropriation of $5,000 allowed for the fiscal year ending June 30,

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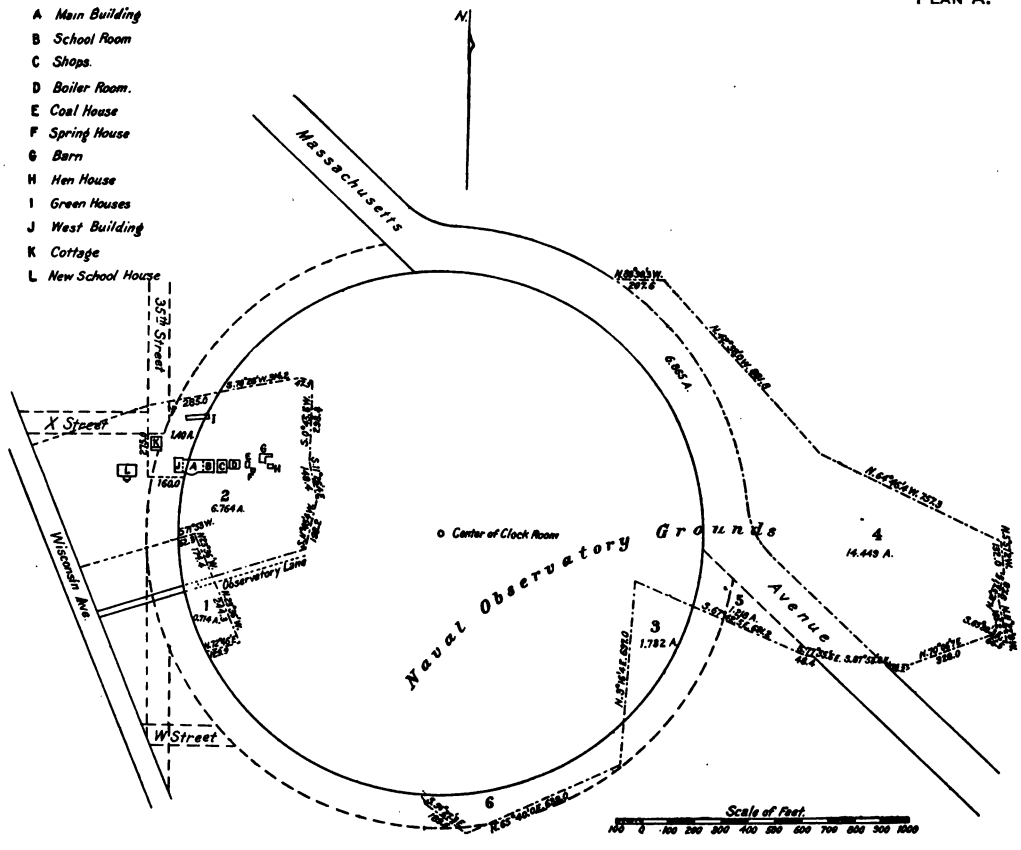
PLAN A.



STATUS OF LANDS LYING WITHIN THE OBSERVATORY CIRCLE, JULY 1, 1904.

1. Philip Young, 0.714 acre, appraised $4,665.28. Condemnation proceedings under way. 2. Industrial Home School, 6.764 acres, negotiations progressing. 3. A. W. Fleming, "Normanstone," 1.732 acres, appraised $15,089.18. Condemnation proceedings under way. 4, 5, 6. Government property outside of the Observatory circle.

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1903, and which was contained in the appropriation bill for the following fiscal year, has been scarcely sufficient for the care of the grounds, and but very little could be done in the way of grading.

A large portion of this property, which must eventually become one of the most conspicuous park reservations of the District of Columbia, is still as undeveloped as when it was a forest. A new portion, known as the Dumbarton estate, which was acquired by the Government in 1902, is still in the crude condition in which it was received. The rapid progress made during the year in grading Massachusetts avenue, now nearing completion, demands some treatment for this contiguous piece of ground at an early date. During the year, finding that the new grade of the avenue circling the Observatory property had created a dam for the surface waters, I requested that a board of medical experts should examine and report upon the sanitary conditions of the reservation. The Department ordered such a board, composed of Medical Director John W. Ross, U. S. Navy, Medical Inspector W. R. Du Bose, U. S. Navy, and Asst. Surg. Joseph A. Murphy, U. S. Navy. The following quotation is made from its report:

> Two pockets, parts of former ravines, one about 300 feet to the east and the other about 400 feet to the north from the Superintendent's quarters have been formed by the work of grading Massachusetts avenue and are objectionable from a sanitary standpoint, being without drainage and forming basins for the collection of surface water and refuse which would be favorable to the development of malarial and other fevers.
>
> In addition there is a depression at east entrance to Observatory grounds, formed by the grading of the same avenue, which it is desirable should be filled level with the grade to insure efficient surface drainage on that portion of the grounds.

The board also reported that—

> at the western limit of the Observatory grounds is located the property of the Industrial Home School, and here the board found a most objectionable, unsightly, malodorous, and insanitary condition, a veritable nuisance, menacing the health of the whole locality.

Continuing, the board recommends:

> 1. That the pockets and depressions in the Observatory grounds mentioned in this report be filled to grade.
>
> 2. That steps be taken to abate the nuisance connected with the sewage disposal of the Industrial Home School.

In order to provide the remedies recommended concerning the Government's property, the Department requested of Congress a special deficiency appropriation of $5,000, which was provided for in the act approved February 18, 1904.

With this allowance there has been removed from the slope on the eastern side of the Observatory property, to fill one of the sections mentioned in this report, covering about 4 acres of ground, an amount of earth equivalent to 30,000 cubic yards. This, at an average cost for such filling of 30 cents per cubic yard, would have cost alone by contract about $9,000.

A road about 550 feet in length, leading from Massachusetts avenue to the buildings within the circle, has been constructed and macadamized, and about 500 feet of old road have been resurfaced. To protect these roads, about 1,250 linear feet of guttering have been laid. Also about 100 square yards of concrete sidewalks have been laid. At contract price all this work would have cost over $10,000.

This piece of work is highly creditable to the foreman, Mr. W. M. Gorman, and when the whole filling is covered by a suitable lawn, it

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will add materially to the appearance of this part of the grounds, which has now become the main entrance to the Observatory reservation.

There still remain two pockets noted by the board to be filled and graded, and an additional appropriation will be required before all the recommendations can be carried out.

Regarding the Industrial Home School property, while the conditions have been bettered by the placing of a pumping plant to carry the sewage of the school into the sewer on the Tenleytown road, the remedy is only partial and can never be satisfactory while the present control is maintained. Knowing that the Government must eventually take this property, as contemplated in the law providing for the present location of the Observatory, the District Commissioners do not take much interest and will not expend much money in keeping it in proper condition.

The lane leading to the Observatory from the Tenleytown road is not a public highway, and while it runs adjacent to two pieces of property belonging to private parties the General Government alone must keep it in repair. Like Massachusetts avenue on the east, it is above the grade of the ground on either side of it, but unlike that avenue, by means of a culvert it passes over a stream of continually running water which rises in the Industrial Home School property, and which, during stormy weather, swollen by the surface waters of an extensive watershed can not be controlled. The result is that the roadbed is frequently submerged or washed away and requires constant repairs.

As a natural sequence to the filling of the depression, there had to be taken into consideration, in connection with the section at the east entrance of the Observatory grounds, the appropriate appearance of the grounds when the place should become one of the beautiful parks of Washington. This required not only the filling of the depression level with the grade of Massachusetts avenue, but the grading of the hill inside the circle from top to bottom. This accounts for the large amount of earth which it was necessary to handle. Further than this, as the main entrance to the grounds was now on grade a considerable portion of the appropriation had to be used for soil, grass seed, etc., to make the appearance conform to other parts of the grounds.

TOTAL SOLAR ECLIPSE OF 1905.

In my last annual report reference was made to the total solar eclipse which is to take place in August, 1905. I respectfully renew my recommendation that the Government should take part in this important event, and call attention to that report and to the reasons therein stated.

The estimates for the Naval Observatory for the past fiscal year contained an item for $6,000 for fitting out an expedition to observe this eclipse, and as Congress failed to make the necessary appropriation, probably owing to the fact that the eclipse would not occur during the fiscal year for which estimates of appropriations were being considered, I recommend that the same amount be again asked for, and that the appropriation be made available at the earliest possible moment after the opening of the coming session of Congress. Past experience shows that the longer the preparation the better the results, and undue delays in preparation are fatal. As the small amount of money asked for contemplates the use of one or more naval vessels and the employment

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of a considerable part of the force they carry to make the observations, it is necessary that the expedition should leave this country at least two months before the eclipse is to occur, August 30, 1905.

A continued study of the subject shows that Spanish astronomers are counting much on the support of interested Governments to make the occasion one of great importance to science. The Madrid Astronomical Observatory has published a map showing the region covered by the sun's total eclipse, and much consideration is being given to the selection of stations. The Spanish Peninsula seems to offer marked advantages for eclipse work, as there are practically three sections which give special meteorological contrasts: First, the eastern section, where the weather conditions are dominated by the influences of the Mediterranean Sea; second, the middle section, a plateau of considerable extent, the altitude of which produces conditions not found on the seacoast; and, finally, the western or mountainous region which breaks up to a large extent the storms passing over the Atlantic Ocean and neutralizes their effect in the other two zones.

It is thought, then, that by selecting one station among the high hills bordering on the Mediterranean to work with some ship as a base, say at Valencia, and another station in the uplands with headquarters on board of a vessel on the northern coast of Spain, the problem of chances would be in favor of excellent results.

Attention is called to the fact that the selection by the Naval Observatory party of two stations widely separated, at Fort de Kock and Solok, in Sumatra, at the time of the last solar eclipse expedition in 1901, brought to our party the only satisfactory weather conditions.

Heretofore it has been the practice to send quite a number of observers from the Observatory, which with our present depleted force is not permissible. The small appropriation asked for for the next expedition contemplates the utilization of a purely naval force, whose military training well equips them for this kind of work, and who, being guided by a few experts from this Observatory, are all sufficient for a large and well-equipped party. The details of the plan outlined above, carried out under naval auspices will, I believe, procure results worthy of the high stand this Observatory has always taken in such expeditions, and will redound to the continued credit of the Navy's service to mankind as a promoter of the arts of peace.

The political possibilities of such an expedition as proposed sent by the United States to the coast of Spain within the next year will, in my opinion, more than compensate for the outlay, even should no satisfactory observations be made of the sun's eclipse, but the chances are so greatly in favor of good weather at one of the two localities selected as to practically assure to astronomy and science in general data of great value.

APPROPRIATIONS.

It should be understood that with the present meager appropriations allowed for carrying on the work the great weakness of the Observatory lies in the inability to keep up to date the reduction of the observations. It is estimated that one observer can keep five computers employed for the period during which observations are taken. Here the object has been to make the best possible disposition of the force at my disposal by having some of the computers act as observers, so as to obtain a maximum amount of observations during the clear nights and then to have both observers and computers devote all their

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attention during bad weather to the reduction of the observations. This arrangement shows the inappropriateness of the designation computer, given by law, for at times the same class of people do both observing and computing work.

I have therefore to recommend that the title of computer be changed to that of assistant, and that the photographer, who is an important assistant in astronomical work, the assistant on the equatorial, and the assistant in spectroscopic work, be also styled assistant. This will harmonize with the titles of employees in the Nautical Almanac department of the Observatory, and best describe the duties performed. In view of the necessities of the case as explained above, and the desirability of having for the Observatory such an organization as is commensurate with its requirements and consistent with its plan of work, I respectfully submit the following, requesting that it may be considered in connection with the next annual estimates:

The permanent force outside of the naval officers assigned to duty at the Observatory to consist of the following:

	Salary.
In the department of astronomical observations:	
1 astronomer	$2,400
1 assistant astronomer	2,000
2 assistant astronomers, at $1,800	3,600
1 assistant astronomer	1,600
4 assistants, at $1,400	5,600
4 assistants, at $1,200	4,800
For miscellaneous computations	10,000
In the department of nautical instruments (including the general storekeeper's duties):	
1 assistant	1,600
1 stenographer	900
In the department of chronometers and time service:	
1 assistant	1,600

As showing the inadequacy of the meager salaries paid at the present time, I quote from the report to the Secretary of the Navy of the Board of Visitors in 1899, which was composed of Senator Wm. E. Chandler, Representative Alston G. Dayton, Prof. Edward C. Pickering, Prof. Geo. C. Comstock, and Prof. Geo. E. Hale, giving a proposed list of observers and salaries for the same, and I have placed in conjunction with this list the corresponding members of the Observatory's staff, with their salaries as they exist at present.

This report reads:

If astronomers are appointed to the Naval Observatory from civil life to succeed retiring professors of mathematics the salaries provided should be sufficient, as recommended by you in that report for 1897, "to make up for the refusal to them of the privilege of retirement and also to secure men of high scientific attainments adequate to the demands of one of the most capable observatories in the world." To secure the services of the ablest astronomers the salaries provided should be slightly larger than those paid in the higher class of university observatories, and account should be taken of the fact that university vacations are much longer than leaves of absence from the public service. The board of visitors recommends the following as a schedule of salaries which could be expected to attract astronomers of the class desired:

Proposed staff.		*Present staff.*	
1 first astronomer	$4,000	1 professor of mathematics	$3,000
1 second astronomer	3,600	1 professor of mathematics	2,700
1 third astronomer	3,200	1 professor of mathematics	2,700
1 fourth astronomer	2,800	1 assistant astronomer	2,000
1 first assistant astronomer	2,400	1 assistant astronomer	1,800
1 second assistant astronomer	2,200	1 assistant astronomer	1,800
1 third assistant astronomer	2,000	1 assistant on equatorial	1,000
		1 assistant in spectroscopic work	1,000

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It should be borne in mind that this report contemplated the elimination of all routine naval work, for which another and expensive establishment would be required, and therefore the professors of mathematics would be relieved of much labor which now falls upon them. In order that the Government may be able to withdraw all line officers from duty at the Observatory in times of public danger the present number of professors of mathematics should be maintained.

It seems that the fourth astronomer of the present staff should have the compensation which would put him on a par with what is known on the staff, as suggested by the Board of Visitors, as the first assistant astronomer. Moreover, since the present occupant of that position is a civilian of fifteen years' service in the Observatory, and is the head of a division in the department of astronomical observations, I recommend that the title of astronomer be established by law, at an annual salary of $2,400.

In this connection I desire to call attention to the fact that within the last two years two professors of mathematics have been detached from the Observatory to meet the demand for instructors at the Naval Academy, with the general understanding that vacancies among the officers of the Navy on shore made necessary by the large increase in the service should be filled by civilians. The vacancies thus created have not been filled.

In the schedule of officers and salaries submitted I have simply provided for the replacement of two professors of mathematics, who acted as astronomers, by one astronomer and by one assistant astronomer, leaving the remaining numbers of the permanent staff of the astronomical department as they exist to-day, but with new designations and a slight increase in their salaries.

The force in the department of astronomical observations not shown in the table above given consists of 1 photographer at $1,200 per annum whose services are extensively required in other departments of the Observatory, 5 computers at $1,200 per annum, and 4 miscellaneous computers at an average of $1,000 (paid out of appropriation miscellaneous computations, $4,000); 9 computers in all.

The growing importance of photography in astronomical observations gives to the photographer at this institution an entirely distinctive signification. His duties are of a scientific character and do not comport with the work commonly designated as photographic. I have therefore, in the annual estimates, recommended a change of his title to that of assistant in the department of astronomical observations. Mr. Peters has by his marked energy and zeal in the work of different departments of the Observatory more than earned the small increase of $200 which it is proposed to add to his salary. In connection with Mr. Hammond and Mr. Dinwiddie he has greatly increased the number of observations of asteroids which have been given to the astronomical world. The new guiding telescope which Mr. Dinwiddie is making out of the old and discarded material found here, as previously mentioned, will give him the means for a still further increase in the output and make his work still more closely connected with that of preparing the Nautical Almanac for publication.

The photographer is also the expert upon which the Department must rely for a knowledge regarding the proper photographic outfits to be furnished to our naval vessels, both cruising and surveying, and for the inspection of the same when they come to the Observatory for

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purchase and when prepared for issue. His direct connection with and importance to the active work of the Navy is thus clearly established and I trust will receive recognition by the Bureau and the Department.

To show the inadequacy of the present force, I beg to make a comparison also used in the report of the Board of Visitors referred to above, giving the approximate number of persons at the Naval and Harvard observatories:

Naval Observatory:	Number.	Harvard Observatory:	Number.
Professors of mathematics	3	Astronomers	6
Assistant astronomers	3	Assistant astronomers	13
Photographer	1		
Assistant on equatorial	1		
Assistant in spectroscopic work	1		
Computers (including miscellaneous computers)	9	Computers	18
Total	18	Total	37

As so many comparisons have been made between the Naval Observatory and the Royal Observatory at Greenwich in the past with reference to the work done, it seems only fair to state the number of the force engaged at Greenwich and also that the Royal Observatory has none of the work of supplying the fleet with navigational instruments other than chronometers.

The report of the astronomer royal for the year ending May 10, 1904, just received, shows that the astronomical staff at Greenwich consists of the following:

Astronomer royal	1
Chief assistants	2
Assistants	6
Established computer (higher grade)	1
Established computers (one vacancy)	10
Supernumerary computers	29
Total	49

I will not compare the results obtained from the two observatories, but I can claim, as does the astronomer royal, that "the record of the work of this Observatory for the past year is the best testimony to the spirit and zeal of the staff to whom great credit is due for the very satisfactory output of the work."

As stated, not only is our force in general drawn upon for incidental work pertaining strictly to the fleet, but one computer is necessarily attached to the department of chronometers and time service, and another, until recently, has been employed in the department of nautical instruments to take the places of naval officers, 4 or 5 in number, who were formerly detailed to this duty. It is probable that another computer must soon be detailed to the department of nautical instruments to keep up with the growing demands on its force.

As has been repeatedly reported, the scant force now attached to the Observatory can not keep up with its requirements. The computations have not only fallen in arrears, but to such an extent as to discourage the management and dishearten the staff. Several of its members have had offers of better positions and have only been kept here by the hope that their services would be recognized by the

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Department by an increase of the appropriations for carrying on its work, and thereby the betterment of their condition. As showing that their efficient and zealous services have been recognized by the astronomical public at large, I can not forbear to quote from a letter to the Superintendent from the eminent astronomer, Dr. S. C. Chandler, of Cambridge, Mass., under date of March 4, 1904. It is as follows:

> This series of intercomparisons of the Saturnian system is remarkable for extent and completeness, as I have no doubt it will prove to be for quality of its results when tested by utilization in perfecting the theory of the satellites. I can not forbear congratulating your Observatory on the evidence which these and previous articles are continuously furnishing in such abundance, to the enrichment of current astronomy, of the value and importance of its renewed, successful and incessant activities.

At least the astronomical department should be relieved of the demand made upon its personnel by the necessities of equipping our large and increased fleet, and its size be restored to what it was before a number of naval officers were withdrawn from the Observatory and its work greatly augmented.

Very respectfully, your obedient servant,

C. M. CHESTER,
Rear-Admiral, U. S. Navy,
Superintendent of the Naval Observatory.

The CHIEF OF THE BUREAU OF EQUIPMENT,
Navy Department.

DIVISION OF EQUATORIAL INSTRUMENTS.

SIR: I have the honor to submit the following report of the division of equatorial instruments for the year ending June 30, 1904:

Asst. Astronomer T. I. King was in charge of the 12-inch equatorial from July 1 to November 15, 1903, at which date I was placed in charge. On December 1, 1903, the division of equatorial instruments including both the 26-inch and the 12-inch was established.

The distribution of the work of this division has been as follows: Professor Skinner, double stars; Mr. Hammond, occultations, comets, the brighter asteroids, and Jupiter's satellites; Mr. Dinwiddie, double stars, comets, the fainter asteroids, the satellite of Neptune, and the satellites of Saturn. With one exception Mr. Hammond has made all the observations with the 12-inch equatorial since November 15, 1903; the other observers have used the 26-inch equatorial.

Messrs. Hammond and Dinwiddie have endeavored to observe as large a number of asteroids as possible in the time not occupied by the observation of the satellites of the major planets. During the year covered by this report observations have been made of 99 different asteroids, of which 49 were observed by Mr. Hammond and 1 by Mr. Rice with the 12-inch equatorial, 44 by Mr. Dinwiddie and 5 by Mr. Frederick with the 26-inch equatorial.

On entering actively upon the asteroid work it occurred to Mr. Dinwiddie to use a Dallmeyer portrait lens of 6 inches aperture and 38 inches focal length which had been procured by the Observatory many years ago for eclipse work. An exposure with this camera of seventy-five minutes is sufficient to obtain a trail permitting the detection of

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any small planet which may be present on the plate. Mr. Peters has cared for this photographic work and has taken nearly all the photographs. Whenever necessary he has determined the places of asteroids by the measurement of the plate with the Stackpole measuring engine.

Two asteroids, which have not been identified with any previously observed, have been discovered by Mr. Peters. The first one, which was photographed December 11, 1903, has received the preliminary designation by the Recheninstitut of Berlin of (1903 NF), and the second one, which was photographed May 11, 1904, the designation of (1904 OF).

Professor Skinner has devoted practically his whole time to work in connection with the preparation of the catalogue of the Astronomische Gesellschaft zone -13° 50′ to -18° 10′, which work is referred to in detail in the report on the division of meridian instruments.

STATE OF THE INSTRUMENTS.

The 26-inch equatorial.—This instrument is in excellent working condition. The electrical illumination of the instrument and dome, designed and installed by Mr. Dinwiddie, continues to give complete satisfaction. Mr. Frederick has recently devised and installed a satisfactory bright field illumination by reflecting light to the inner surface of the objective by means of a prism within the telescope tube just outside of the cone of rays.

The 12-inch equatorial.—The mounting of this instrument is defective in several particulars. The chief difficulty is with the driving clock, which is so weak and ineffective that observations which demand the use of clockwork are made with great difficulty.

The constants of the instruments.—The constants of the two equatorials have been frequently determined for the 26-inch by Mr. Frederick, for the 12-inch by Mr. Hammond, and show that the instruments are quite steady.

Table of constants.

26-INCH EQUATORIAL.

Date.	Temperature.	ξ	η
	° F.	″	″
1903, October 13	60	−72	+114
1904, February 3	24	−61	+113
1904, May 7	65	−72	+115

12-INCH EQUATORIAL.

1903, December 6	30	+63	+29
1904, January 27	21	+82	+28
1904, April 4	40	+68	+27

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OBSERVATIONS WITH THE 26 INCH EQUATORIAL.

Asteroids:

(42) Isis	4	(350) Ornamenta	3
(46) Hestia	3	(362) Havnia	5
(47) Aglaja	3	(371) Bohemia	3
(49) Pales	1	(374) Burgundia	4
(65) Cybele	2	(379) Huenna	5
(84) Klio	1	(381) Myrrha	3
(90) Antiope	1	(382) Dodona	3
(108) Hecuba	1	(386) Siegena	5
(153) Hilda	1	(388) Charybdis	5
(154) Bertha	4	(393) Lampetia	5
(156) Xanthippe	3	(403) Cyane	5
(161) Athor	3	(409) Aspasia	5
(163) Erigone	8	(417) Suevia	3
(199) Byblis	3	(420) Bertholda	4
(207) Hedda	5	(423) Diotima	2
(225) Henrietta	3	(426) (1897 DH)	2
(241) Germania	2	(449) Hamburga	4
(271) Penthesilea	4	(454) Mathesis	4
(301) Bavaria	2	(455) Bruchsalia	4
(317) Roxane	5	(478) Tergeste	4
(332) Siri	5	(490) (1902 JP)	2
(333) Badenia	7	(492) (1902 JR)	2
(334) Chicago	3	(1903 NF)	5
(339) Dorothea	4	(1904 OF)	6
(343) Ostara	3	—	174

Satellites of Saturn:

Tethys-Mimas	3
Tethys-Enceladus	37
Dione-Tethys	33
Rhea-Tethys	47
Titan-Tethys	40
Hyperion-Tethys	6
Japetus-Tethys	18
Rhea-Dione	30
Titan-Rhea	44
Hyperion-Titan	18
Japetus-Titan	48
Rhea (fixed star)	13
—	337

Satellites of Uranus:

Titania	11
Oberon-Titania	9
Oberon	2
—	22

Satellite of Neptune	8
Comet 1889 V (Brooks)	35
Comet 1904 *a* (Brooks)	2
Comparison stars	3
Double stars	165
Photographs of asteroid fields	96
Variable stars	4
Spot on Saturn	2
Occultation of star by the Moon	1
Total	849

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OBSERVATIONS WITH THE 12-INCH EQUATORIAL.

Asteroids:

(2)	Pallas	2	(79)	Eurynome	3
(5)	Astraea	5	(80)	Sappho	6
(7)	Iris	5	(81)	Terpsichore	3
(8)	Flora	5	(89)	Julia	5
(10)	Hygiea	6	(105)	Artemis	4
(11)	Parthenope	5	(110)	Lydia	4
(14)	Irene	5	(113)	Amalthea	5
(15)	Eunomia	9	(114)	Kassandra	4
(18)	Melpomene	4	(119)	Althaea	5
(19)	Fortuna	5	(139)	Juewa	4
(21)	Lutetia	5	(182)	Elsa	5
(22)	Kalliope	5	(192)	Nausikaa	5
(23)	Thalia	6	(196)	Philomela	5
(26)	Proserpina	2	(198)	Ampella	7
(27)	Euterpe	5	(202)	Chryseis	4
(28)	Bellona	5	(270)	Anahita	10
(30)	Urania	5	(306)	Unitas	5
(37)	Fides	7	(313)	Chaldaea	5
(40)	Harmonia	3	(324)	Bamberga	8
(51)	Nemausa	5	(345)	Tercidina	5
(53)	Kalypso	7	(349)	Dembowska	6
(56)	Melete	5	(387)	Aquitania	4
(57)	Mnemosyne	5	(405)	Thia	1
(63)	Ausonia	5		(1904 NY)	14
(64)	Angelina	5			259
(67)	Asia	6			

Satellites of Jupiter:

I-II		38	II-III		20
I-III		24	II-IV		20
I-IV		14	III-IV		15
					131

Phenomena of Jupiter's satellites	45
Comet 1903 *a* (Borrelly)	15
Comet 1904 *a* (Brooks)	35
Miscellaneous stars	13
Diameter of Saturn	1
Diameter of Jupiter	4
Diameter of Venus	2
Occultations of stars by the Moon	23
Total	528

TABLES FOR DIFFERENTIAL REFRACTION.

The tables for differential refraction for the latitude of the Naval Observatory, referred to in the last annual report, have been completed by Mr. Frederick. One set of these tables is arranged for differences of right ascension and declination and the other set for position angle and distance. The tables will be published as an appendix to a volume of the publications of the Naval Observatory.

VISITORS.

As in former years, the 12-inch equatorial has been devoted one evening a week, and occasionally on other special evenings, to afford a view of telescopic objects to persons admitted to the Observatory by permit. Mr. Peters has been assigned to the duty of caring for these visitors.

The number of visitors received during the year has been 1,087 on 50 different evenings.

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PERSONNEL.

A. N. Skinner, professor of mathematics, United States Navy, in charge of the 26-inch equatorial from July 1, 1903; temporarily in charge of the 12-inch equatorial November 15 to 30, 1903; in charge of division of equatorial instruments from December 1, 1903.

T. I. King, assistant astronomer, in charge of 12-inch equatorial July 1 to November 15, 1903.

John C. Hammond, assistant astronomer, from December 1, 1903.

W. W. Dinwiddie, assistant in spectroscopic work.

C. W. Frederick, assistant on equatorial.

Gustave Harrison, laborer.

Very respectfully,

A. N. Skinner,
Professor of Mathematics, U. S. Navy, in Charge.

The Superintendent of the Naval Observatory.

DIVISION OF MERIDIAN INSTRUMENTS.

Sir: I have the honor to submit the following report on the work of the division of meridian instruments for the fiscal year ending June 30, 1904:

The observations made in this division up to September 4, 1903, are reduced and ready for publication, and those made since that date are in various stages of reduction.

THE 6-INCH TRANSIT CIRCLE.

This instrument was in active operation only for a portion of the year, during which time it was devoted to the determination of the right ascensions and declinations of the sun, moon, and planets, and a few miscellaneous stars. The miscellaneous stars observed were used as comparison stars in the observation of asteroids with the 12-inch equatorial.

All the observations made with this instrument were strictly differential, and a sufficient number of ephemeris stars were observed with each one of the objects, whose position was to be determined to obtain the clock corrections and the equator points.

The number of observations from July 1, 1903, to September 4, 1903, is as follows:

Ephemeris stars	487
Sun	30
Moon	24
Mercury	18
Venus	28
Mars	1
Jupiter	6
Saturn	14
Uranus	6
Miscellaneous stars	17
Total	631

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Of these observations there were made by—

Professor Littell	175
Mr. Rice	217
Mr. Brown	239
Total	631

A very thorough discussion of the variation of the constants of this instrument with the temperature, extending over the period from September, 1902, to September, 1903, has been made by Professor Littell, and the results will appear in the Introduction to Volume IV, Part I, Publications of the United States Naval Observatory, Second Series, now in press. He finds that the collimation constant exhibited great stability, showing a variation of $+0^s.0007$ for each increase of 1° F.; that the azimuth was subject to an annual variation of $-0^s.011$ and to a daily variation of $+0^s.005$ for each increase of 1° F., and that it was impossible to connect the changes in level with the changes in temperature.

Since this instrument has been out of commission it has received a thorough cleaning, and the location and erection of a south mark has been commenced.

THE 9-INCH TRANSIT CIRCLE.

Observing with this instrument was commenced on September 3, 1903, after a number of changes, spoken of in my last annual report, had been completed.

This instrument has been devoted to the determination of the right ascensions and declinations of the sun, moon, planets, the stars of Newcomb's Suggested List of Fundamental Stars, and the stars of Gill's Catalogue of 2,798 Zodiacal Stars, with the addition of about 350 stars not in Gill's list.

In the observations of the zodiacal stars, and of the moon and the planets when observed in connection with those stars, one observer takes the transits and makes the micrometer bisections, while a second one sets the instrument, reads the microscopes, and keeps the record. In the other work the observer works alone, except on the sun and occasionally on the moon.

The reductions are so carried on that each observation will give the right ascension and declination of the object observed, the plan of observing ephemeris stars for clock corrections and equator points only having been discontinued.

The number of observations from September 3, 1903, to June 30, 1904, is as follows:

Zodiacal stars	5,590
Standard stars	4,670
Screen stars for personal equation	436
Astronomische Gesellschaft Zone zero stars	4
Astronomische Gesellschaft Zone zone star	1
Sun	141
Moon	106
Mercury	51
Venus	95
Jupiter	8
Uranus	6
Neptune	15
Total	11,123

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Of these observations there were made by—

Professor Skinner	5
Professor Eichelberger and Mr. Rice	172
Professor Eichelberger and Mr. Yowell	5,992
Professor Eichelberger and Mr. Morgan	219
Professor Eichelberger	15
Professor Littell (three months)	1,212
Mr. Rice	1,294
Mr. Brown	1,458
Mr. Morgan (seven months)	756
Total	11,123

To observe a star of the second, third, or fourth magnitude with the 9-inch transit circle with the full aperture is exceedingly unsatisfactory, so that the instrument has been provided with two wire-gauze screens attached to the object-glass end of the telescope, so mounted that the observer at the eye end can easily and quickly screen or unscreen the object-glass, either or both screens being used. One screen reduces the brightness of a star two and a half magnitudes, and the other one five magnitudes. All the work of making and attaching the screen apparatus was done at the Observatory by Mr. Cleve. Beginning with September 3, 1903, all stars have been observed as between the sixth and ninth magnitudes. The screen has been found to be of advantage in night observations of the moon and also in observations of Jupiter.

Another improvement in the method of observing is the using of both a south and a north meridian mark. With the collimators and the marks two independent determinations of the collimation are obtained, and after a value of the collimation has been adopted from these two sets the two marks give two determinations of the azimuth.

The south collimator for the 9-inch transit circle was not provided with any means of readily adjusting its vertical thread, and as the position of the image of that thread as viewed in the transit circle was much affected by changes of temperature, the collimation was frequently determined when the distance of the image from the middle thread of the transit circle reticule was probably too great or too small for the best results. Mr. Cleve, the instrument maker, has remodeled the eye end of the collimator so that now the vertical thread can be easily and quickly adjusted to any desired position.

The circle microscopes were provided with new micrometer screws by Mr. George N. Saegmuller, in May, 1904, as the old ones had become much worn.

In order to protect the thermometer shelter from the direct rays of the sun during the early morning and late afternoon in summer, a shed of single louvre work has been built over it. This shed is open on the entire north side, and in order that the thermometer might the more quickly take up any change in the temperature of the outside air, the original shelter was changed to single louvre work, and its north side was hinged so that it could be open during work at night.

The series of measures with an axial collimator for the determination of the irregularities of the pivots of this instrument, referred to in my last annual report, indicates a slight irregularity. If the observations are reduced on the assumption that the pivots are perfect, the time of transit thus obtained must be corrected by a quantity varying between $+0^s.02$ and $-0^s.02$.

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Several series of observations by the different observers to determine their personal equations depending on the magnitude of a star by the use of wire-gauze screens give the following results:

The amount by which the time of transit of a star is observed later, when its brightness is reduced two and a half magnitudes.

Observer.	Number of stars observed.	Difference in time of transit.
		s
Eichelberger	59	+0.025
Littell	52	+0.009
Rice	85	+0.009
Brown	105	+0.030
Morgan	91	+0.045

The following values of the horizontal flexure applicable to observed zenith distances have been determined by the use of horizontal collimators:

Date.	Observers.	Horizontal flexure.	Temperature.
1904		" "	° F.
Jan. 25	Eichelberger and Yowell	−1.09 ±0.02	34
Apr. 11	.....do	−1.13 ±0.03	56

THE CLOCKS.

The new clock, Riefler No. 70, with a nickel-steel pendulum and inclosed in a glass air-tight case, made by Riefler, of Munich, was received at the Observatory in July, 1903. It was set up by Mr. Hutterly, a local clock maker, in the clock vault, and was installed as the standard sidereal clock on September 1. For several weeks it worked satisfactorily, but since that time it has given some trouble. While the case was perfectly air-tight for at least six weeks, since November it has been impossible to maintain a constant pressure in it. A second difficulty has been that the electric winding apparatus would at times fail for a few seconds, then recover itself and work perfectly for days without any change whatever being made in the batteries. A third difficulty has been the occurrence of extra breaks on the chronograph at the time of winding of the clock.

The use of this clock was discontinued on May 19, and it has been returned to the maker, at his request, in order that he may correct the difficulties.

Another clock, Riefler No. 60, was set up in our clock vault in March for testing before shipment to its station at Guam. This clock is a duplicate of the former one except that it has a maintaining spring. Its case leaked from the first, but now, since its joints have been worked over by Mr. Cleve, it seems to be air-tight. This clock also produces occasionally extra breaks on the chronograph at the time of the winding of the clock, but it has never failed to wind since we have had it. It has been used as the standard sidereal clock since May 19.

The following rates are deduced from a preliminary reduction of the observations, in which the irregularities of the pivots and the effect of

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the screens used in observing are neglected and in which a preliminary set of relative personal equations of the observers is used:

Rates of Riefler No. 70.

Date.	Daily rate.
1903	s
Sept. 10.4	−0.04
11.6	.08
12.5	.06
13.8	.08
14.4	.07
15.6	.10
16.3	.11
19.5	.12
21.6	.14
22.5	.17
23.5	.05
24.5	.11
25.5	.08
26.3	.13
27.8	.11
28.5	.11
29.6	.08
30.5	−0.12
Oct. 1.5	

GENERAL REDUCTIONS.

The order of the Superintendent, dated November 27, 1903, states that—

> The committee on editing and printing shall consist of * * *, the head of the division of meridian instruments to be the secretary.
>
> The secretary to the committee shall be the custodian of all records in the archives of the department of astronomical observations, and shall have charge of the proof reading and the preparation of printer's copy of this department and of such reductions of observations and checking as can not be done in the division in which the observations are made.

Astronomische Gesellschaft Zone Catalogue —13° 50′ to —18° 10′.—The precessions and secular variations for 1900.0 for this catalogue are finished. The 1,431 stars in Bessel's Zones that are also in this catalogue have been reduced to 1900.0 for purposes of comparison, and a similar reduction of the stars in Lalande's Histoire Celeste, Argelander's Southern Zones, and Münchener Sternverzeichniss I and II is in progress. This work is being carried on under the direction of Professor Skinner, and much of it is being done by him personally.

Washington Zone Catalogue.—The work of revising the Washington Zone Observations of 1846–1849, as described in detail in my last annual report, has been pushed as much as the limited force of computors and the press of other work would allow. The comparison of the mural zones with the Cordoba General Catalogue has been completed, and from this comparison zone corrections for about half the zones have been deduced. These corrections have been applied to all the stars of the first 25 zones. The preliminary revision of the transit zones is about two-thirds completed and about one-fourth of the zones have been compared with the Cordoba General Catalogue.

The 1,000 unpublished observations made with the meridian circle in 1851–52 have been reduced to 1850.0 and the reduction of the 3,500 unpublished observations made with the same instrument in 1847–48 is well advanced. The reductions of these unpublished observations are being carried on under the direction of Professor Littell.

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In the published results from the mural zones the right ascension of nearly 4,000 stars and the declination of over 4,000 stars have been changed. All changes in the published positions are made only after a personal inspection by Professor Eichelberger.

Printing.—Since the last report, Volume V, Publications of the United States Naval Observatory, Second Series: Meteorological Observations and Results, 1893–1902, has been published. Parts I and II, Volume IV, are in type, and the printer's copy of Part III is more than half ready. The plates for the illustrations of Appendix I, Volume IV, Reports on the Total Solar Eclipses of 1900 and 1901, are being made, and it is expected that the presswork will be begun this summer.

PERSONNEL.

The following members of the Observatory force have been attached to this division at some time during the year ending June 30, 1904, the first six principally as observers, the remainder as computers engaged in general reductions under the direction of the committee on editing and printing:

Prof. William S. Eichelberger.
Prof. Frank B. Littell, for five months.
Asst. Astronomer Herbert L. Rice.
Computer William M. Brown.
Computer Everett I. Yowell.
Computer Herbert R. Morgan, for seven months.
Computer John C. Hammond, for three months.
Computer Eleanor A. Lamson.
Computer Arthur B. Turner, for one week.
Miscellaneous Computer Etta M. Eaton.
Miscellaneous Computer Delonza T. Wilson, for one month.
Miscellaneous Computer Charles E. Yost, for ten weeks.
Miscellaneous Computer Charles N. Moore, for ten weeks.
Miscellaneous Computer Alice M. Gray, for seven months.
Miscellaneous Computer Ella A. Merritt, for six months.
Miscellaneous Computer Florence A. Graves, for six months.
Miscellaneous Computer Matt Frederickson, for three months.
Miscellaneous Computer Perez Fisch, for three months.
Miscellaneous Computer L. Adolph Richards, for three months.
Miscellaneous Computer Jesse Pawling, jr., for one month.

Only a small portion of Mr. Hammond's time was spent on general reductions, the larger portion being given to making asteroid observations on the 12-inch equatorial and reducing the same.

The large number of miscellaneous computers is due to the inability to secure eligibles for these positions during the early months of the fiscal year. The regular number is four.

In conclusion I desire most heartily to commend the willingness with which each and every duty assigned to members of this division is undertaken, and the painstaking faithfulness with which it is performed, and further, to call attention to the fact that the value of the service performed by the computers doing duty as observers is far in excess of the renumeration they receive.

Very respectfully,

W. S. EICHELBERGER,
Professor of Mathematics, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

SIR: The alt-azimuth instrument was in charge of Mr. Hill until December, 1903, when the division of the alt-azimuth instrument was established by the Superintendent with a view to enlarging the work of this instrument by assigning to it an observer unhampered by other observing duty. From July 1 to December 1, 1903, Mr. Hill secured 465 vertical-circle observations of stars of a list selected from those recommended by the Paris Conference.

After the establishment of the new division it was decided to take up the observations of all of the stars of Newcomb's Suggested List of Fundamental Stars culminating here at zenith distances less than 75°. The number of stars on the list is 1,186 above the pole and 136 below the pole. When the zenith distance is greater than 10°, a double observation is obtained, one a few minutes before and one a few minutes after meridian passage, the instrument being reversed in the interval. The observation is made by noting the time of the oblique transit of the star over the horizontal thread at the middle of the field. For stars of smaller zenith distances the instrument is clamped in the meridian and used as a meridian circle. By making the bisections at the side of the field the observer is able to secure a double observation with reversal. The number of vertical-circle observations secured from December 1, 1903, to June 30, 1904, is 1,030, making a total for the year for this instrument of 1,495.

The observations have not been sufficiently reduced to determine the quality of the resulting declinations nor the relative efficiency of the two methods of observation.

The two alidade levels and the striding level were tested during the winter, and as the striding level tube showed some superiority to the upper alidade level, it has been substituted for it.

The determination of the division errors of the circle is planned for the near future. The circle will also be shifted at intervals.

In order to maintain the verticality of the axis of the instrument it has been found necessary frequently to adjust the base screws by small amounts, and to facilitate this adjustment they have been provided with pointers and graduation by the instrument maker of the Observatory.

The necessity of a more suitable house for the alt-azimuth and of the erection of collimators has been noted in several previous reports, and I urge the desirability of early action on these matters.

Very respectfully,

FRANK B. LITTELL,
Professor of Mathematics, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

SIR: For the year ending June 30, 1904, the following is respectfully submitted as the report upon the operations in my division:

The prime vertical transit instrument having been in constant use since the spring of 1893, it was decided at the beginning of the fiscal year to dismount it for general cleaning and repairs. Specifications outlining the conditions that demanded rectification were submitted to

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two astronomical instrument makers. The estimate of The Warner & Swasey Company, of Cleveland, Ohio, being the lower as well as the more satisfactory, was accepted.

An examination of the instrument after it had been taken down, as well as previous knowledge of its condition, indicated that the following repairs were required:

To refigure and repolish the pivots; to cut new scores in the reticule plate, and replace the system of transit threads by a more elaborate one; to remove the lacquer from the outside of the cube and the two tubes, and the dead black from the inside; then to repaint all parts, and reproduce a dead black on the inside of the cube and tubes; to clean the micrometer box, including the screw and the micrometer head, and the setting circles; to reface the two wyes; and to resurface the friction rollers upon which the instrument rests.

During the time the instrument was away for the above repairs, Mr. Cleve, assisted by Mr. Coulon, dismounted the reversing apparatus that is fastened to the pier beneath the floor of the observing room, and gave each part a thorough cleaning with gasoline. They also removed the paint from the upright supports that hold the instrument when it is being reversed, the level frame, the level crane, and its different parts. These were all repainted to correspond to the other portions of the instrument as repaired by the instrument makers.

Mr. Cleve has also remodeled the mercury basin to prevent, as much as possible, tremors reaching the thin film of mercury therein.

In the specifications sent to bidders special emphasis was laid upon the requirement that in figuring the pivots they must be polished and lapped to as near true cylinders as it is possible to make them. The Warner & Swasey Company, with the advantage of their fine machines, have shown great skill in reforming the pivots, and they have produced two as nearly true cylinders as modern mechanical methods can obtain.

The system of transit threads formerly in use consisted of two tallies of seven threads each, spaced on either side of the thread that approximately marks the middle of the field and with sufficient interval therefrom to permit the instrument to be revolved 180° after the star had passed the thread nearest to the middle thread and before it would reach the same thread on the opposite side of the field. The instrument can be reversed without haste, then reset to the proper zenith distance of the star, within a period as short as thirty seconds of time.

The equatorial interval of the threads was about three seconds. A star on the prime vertical, and relatively near the zenith, moves quite slowly. For example, α Lyræ formerly consumed eleven minutes in making a complete transit from the first thread to the last one on the reversed set. In the new reticule, devised by the observer, the space between threads has been so reduced that it takes the same star only five minutes to transit the same number of threads.

One of the possibilities in prime vertical transits made in accordance with the Struve method, i. e., in which the instrument is reversed at each vertical for the purpose of eliminating the error of collimation, is that the collimation may change in an interval as large as 11 minutes. To guard against that possibility the scores on the reticule plate have been placed with a width of only $\frac{1}{250}$ of an inch between each. The observer has long been convinced that the reticule should be so formed that transits direct and by reflection would be possible. Advantage

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was taken while the instrument was dismounted to have scores made for two additional tallies, of seven threads each, placed outside of those mentioned, and so spaced therefrom that sufficient time would be allowed after a star had transited one of these outer sets to repoint the telescope for an observation direct or by reflection over one of the inner sets. In other words, the method of procedure is to observe a star direct over one of the outer tallies, then repoint the telescope and observe over one of the inner sets by reflection, reverse the instrument and go through the same process. By that scheme the error of level of the instrument is eliminated from the transits, whatever may be its value, as is also the inequality of pivots, and the mean of the two resulting declinations observed direct and by reflection is free from any visual determination of the level by aid of a spirit vial. A complete check is had upon a change in the remaining instrumental error, the azimuth, from readings made on the azimuth mark through the long focus lens, both before and after the transit of the object across each of the two verticals.

The instrument was out of use from August 15 until November 12, 1903.

Observations of the list of 390 stars, for their declinations, mention of which was made in the last annual report, were completed in February, 1904. Five observations have been secured of each star, as this number is considered ample for the purpose of giving a good position. The majority of these stars have not been observed for the past forty years, except for the two or three observations secured in the zone observations made under the direction of the Astronomische Gesellschaft. In a few instances I have found evidence of proper motion.

The completion of observations of these faint stars has led to a study of the accordance of declinations of the two classes of stellar images, bright and faint, when observed in the prime vertical. The data that have been accumulated indicate very clearly that better and more accordant declinations and the periodic changes in these may be secured from fainter than from brighter stars. These two terms include, first, stars between the magnitudes 5 and 7.5 and, second, between the magnitudes 1 and 3.5.

Commencing in February last the observer has adopted the polygon method of observing with the instrument for the purpose of obtaining the variation of latitude and a correction to the constant of aberration, which method has been used with such marked success by zenith telescope observers. Four groups of four stars each have been selected. The average right ascension for each group has been made as nearly as possible six, fourteen, eighteen, and twenty-two hours, respectively. The average magnitude of the stars in each of the four groups is 6.8, 7.2, 7, and 7. It is not practicable to include more than four stars in a group, because it occupies so much more time to observe a star in the prime vertical than it does in the meridian either with a zenith telescope or with a meridian or vertical circle. It will take from seven to eight hours to secure transits of the stars in two groups when both are observed on the same night. The magnitude of α Lyræ and θ Aurigæ, which stars are included in two of the groups, will be reduced by the aid of a wire screen to conform to the other stars in their respective groups.

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With the prime vertical transit instrument there have been secured during the year 314 observations. There have been made to date, from the commencement of observations at this Observatory, 1,095 observations of α Lyræ, and this closes the eleventh year of continuous observations with the instrument by the same observer.

The following is a statement of the condition of the reductions:

The transits are entered on the reduction sheets up to January 24, 1904. They are completely reduced, and finally checked up to the commencement of 1903. They are entered on the printer's copy up to January 1, 1902. During the year I have carried through the complete reduction of 667 transits. The checking of that work has, for the most part, been done by Miss Lamson. The annual precessions and the secular variations for the epoch 1900, for the 390 stars, have been computed by myself, and they are now ready to be checked.

An additional computation that is nearing completion is a determination of the latitude of the instrument, from observations extending over the past ten years, basing it upon the three standard systems of declination now at the service of astronomers, namely, that of the Fundamental Catalogue prepared in the United States Nautical Almanac Office, that of Prof. Lewis Boss as published in the Astronomical Journal No. 531, and that of Dr. A. Auwers, after applying the corrections to his star places as printed in the Astronomische Nachrichten Nr. 3927–9. The stars common to these three systems have been reduced to each mean year covered by the prime vertical observations.

With these data the difference between catalogue declination and observed declination has been taken for all individual observations. From about 30 of those differences a well-determined value of $\Delta\phi$ will be secured, which is to be applied to the latitude used in making the reductions. The above method will be followed so as to secure well-determined latitudes extending over the entire period of this series of observations, and each based upon the mean of 30 values of $\Delta\phi$. To each of those determinations and for each system will be applied the latitude variation that has been computed and published both by Dr. S. C. Chandler and Doctor Albrecht. The probable error of the latitude as obtained from these three systems will then be computed. So far as the observations are concerned the result of this discussion, based on a continuous series of ten years' observations, will be interesting in showing which of the three systems has the smallest probable error when all the star places used are referred to the same point in the heavens. The results of the discussion will be printed in one of the astronomical journals.

Observations were continued with the vertical circle until December 1, 1903, when, by order of the Superintendent, I was relieved from charge of the instrument. From July 1 until November 30, 1903, 465 vertical circle observations were secured.

The reductions are now eighteen months in arrears, not to mention the checking of the copy for the printer, extending over the past ten years. The copy has been made by myself, and it will have to be read by two persons before it goes to the printer. It contains over 3,000 observations. Moreover, the first ten years' work should be reduced for the purpose of determining the constant of aberration. In that discussion over 1,400 equations of condition will have to be computed.

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I wish to express my appreciation of the assistance I have received from Miss Lamson, who has practically done all the checking on the work after I had made the first reductions. Her computations and checking have been both thorough and accurate.

Very respectfully,

GEO. A. HILL,
Assistant Astronomer, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

THE PHOTOHELIOGRAPH.

SIR: I have the honor to report that during the fiscal year ending June 30, 1904, the sun has been photographed with the photoheliograph on two hundred and ten days, and solar spots and faculæ were observed on these plates on one hundred and ninety-two days. This is an increase over the preceding year of eight days on which the sun has been photographed, and of ninety-three days on which spots were observed.

An enormous group of spots, the largest since 1898, made its appearance on October 5, 1903. This was announced from here, and received much notice in the daily and scientific papers and the magazines. During the year several other large groups, though smaller than the one just mentioned, were observed but were not publicly announced. The definition and quality of these solar photographs, owing to the exact determination of the temperature variation of the focal plane, is very excellent.

As lenses of the type used for this sun work are also employed for large scale photographs of the inner corona on eclipse expeditions, it was decided to procure a new, larger, and improved lens, for which the contract has been let. The aperture is to be 7.5 inches and the focal length 65 feet. This length will give an average solar image of 7 inches diameter instead of 4¼ inches, which is the size given by the present lens. This lens is to be of triple construction, and corrected for both the visual and actinic wave-lengths of light. This correction will permit the use of either ordinary or orthochromatic photographic plates with equal advantage, since the new lens will bring all wave-lengths practically to one focal plane. In eclipse work this is of especial advantage, as the light from the chromosphere and prominences will come into exact focus.

Very respectfully,

GEO. H. PETERS,
Photographer, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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LIBRARY.

SIR: I have the honor to submit the following report on the library for the fiscal year ending June 30, 1904:

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1903	18,870	4,053	22,923
Accessions	406	80	486
Contents July 1, 1904	19,276	4,133	23,409

Of the accessions, 287 were received as exchanges and 199 were purchased.

The following publications were distributed:

Publications, Second Series, Volume V, containing Meteorological Observations and Results, 1893–1902.

Report of the Superintendent for 1903.

Since July 1, 1903, all the scientific pamphlets have been catalogued.

In regard to the small number of purchases reported during the last five years, it should be stated that the prices of higher class technical works are much higher than those of ordinary books. In the literature of mathematics and astronomy the Observatory library is the most complete and valuable in the country. It is especially rich in the serial publications of the older scientific bodies of Europe and in the scientific journals of the last century. But unfortunately there are gaps in some of the series. Most of the books required to fill these gaps are rare and difficult to obtain, and it is highly important to obtain them before they become rarer and more costly.

The library is used not only by the scientific bureaus of the Government and the institutions of learning in Washington, but its value is recognized and it is consulted by scientific workers from distant parts of the United States. About half of our present appropriation is expended in subscriptions to serial publications dealing in astronomy. And after desk books, upon which there is considerable wear and tear, are provided for the various departments, including the Nautical Almanac, there is but little left for the purchase of either old or new books or to provide the necessary fixtures for the library. Therefore, in order that the library may be kept up to its present standard, the amount of $1,000, the annual appropriation for the fiscal years 1887 to 1898, is considered essential for the future.

The shelving provided for the library when the Observatory removed to its present site accommodates but two-thirds of the present collection. The other third is partly stowed away on unstable shelves in the old record room, out of reach, and insufficiently lighted. The remainder is in the basement, surrounded by steam pipes, lumber, and packing materials. It seems that the time has come when some steps should be taken to provide modern fireproof shelving for the overflow. Whether this could best be accomplished by constructing another gallery and extending the alcoves in the rotunda or by erecting stacks there or elsewhere is a question requiring careful consideration.

Very respectfully,

WM. D. HORIGAN,
Librarian.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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DEPARTMENT OF THE NAUTICAL ALMANAC.

SIR: I have the honor to submit the following report of the operations of the Nautical Almanac Office for the fiscal year ending June 30, 1904:

PRINTING.

The following publications were received during the year from the Government Printing Office:

The American Ephemeris and Nautical Almanac for 1907, first edition, 1,010 copies.

The American Nautical Almanac for 1907, first edition, 510 copies.

The Pacific Coaster's Nautical Almanac for 1904, first edition, 1,786 copies.

The American Ephemeris and Nautical Almanac for 1904, second edition, 729 copies.

The American Nautical Almanac for 1903, second edition, 152 copies.

The American Nautical Almanac for 1904, second edition, 2,340 copies.

DISTRIBUTION OF PUBLICATIONS.

During the fiscal year ending June 30, 1904, the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris	793	1,078	1,871
American Nautical Almanac	2,711	269	2,980
Atlantic and Pacific Coaster's Nautical Almanac	1,625	42	1,667
Astronomical Papers	14	64	78

The proceeds of sales, amounting to $1,847.13, have been deposited with the Treasurer of the United States to the credit of public printing.

THE AMERICAN EPHEMERIS.

I have to report that the current work of this office is fully up to date, the American Ephemeris for 1908 and the American Nautical Almanac for 1908 being about one-half in type, thus insuring their issue on January 1, 1905, the earliest date authorized by law.

The omission from the British Nautical Almanac of the Lunar Distances has caused the cancellation of an agreement entered into some years since whereby the work of preparing these computations was divided between the two offices. The publication of the Lunar Distances is, however, continued in the American Ephemeris.

MISCELLANEOUS.

Recent legislation by Congress has reduced far below its needs the number of copies of the American Ephemeris authorized by law to be supplied to the Navy Department for sale and distribution. It has been necessary to supply the deficiency by requisition upon the funds

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of the Navy Department, although the law provides that the proceeds of the sale of these copies be deposited to the credit of the general printing fund. It is respectfully suggested that legislation be recommended providing for the printing of the full number of copies needed for sale and distribution.

Very respectfully,

WALTER S. HARSHMAN,
Professor of Mathematics, U. S. Navy,
Director Nautical Almanac.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DEPARTMENT OF NAUTICAL INSTRUMENTS.

SIR: I have the honor to submit the following report of the department of nautical instruments for the fiscal year ending June 30, 1904:

The supply of nautical instruments to vessels in commission, or about to be commissioned, to navy-yards and shore stations, wireless telegraph stations, the naval militia, etc., has proceeded regularly and promptly, in accordance with the shipment orders received.

Invoices for all expenditures have been promptly prepared and forwarded, and since April 1, 1904, bills of lading have been prepared and issued with all shipments made by either freight or express.

Requisitions for instruments necessary to replenish stock have been prepared and the instruments purchased have been inspected, marked, and stored ready for issue.

In January a survey was held on a large number of instruments which had been returned to the Observatory from ships and stations during the year, the invoiced value of which exceeded $11,000.

The following facts, as bearing on the supply of nautical instruments to naval vessels, are deemed worthy of notice, viz:

(*a*) A board for the trial of prismatic binoculars convened at the Observatory by order of the Chief of the Bureau of Equipment on October 22, 1903, and after an examination and test of samples of glasses submitted by various American makers and agents of foreign makers reported that, all things considered, it was deemed most advisable to purchase for naval use the prismatic binoculars made by The Warner & Swasey Company, of Cleveland, Ohio. Since then this firm has devised amber shade-glasses to be fitted to the eyepieces of its binoculars which are found to have the valuable feature of deepening contrasts without in any way detracting from the definition. Twelve pairs of these glasses thus fitted were purchased for issue to naval vessels and 50 more have been ordered.

(*b*) The specifications for deck clocks have been revised and specifications prepared for boat clocks, all of which are of such a character as to insure naval vessels being supplied with the best marine clocks which the market affords and at a very reasonable cost.

(*c*) Steps have also been taken to insure the issue to ships of a better and more reliable class of thermometers than formerly. Of 325 air and 320 water thermometers purchased since October, 1903, only one of each failed to pass inspection.

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(*d*) In January a new sextant testing machine was received from the makers, the Keuffel & Esser Company, of New York. This is a handsome, accurate, and finely finished instrument, by which the long and arduous labor of inspecting sextants has been lightened and greatly facilitated.

Your attention is most urgently invited to the pressing need of increased expert and clerical assistance in this department of the Observatory. The officer in charge has, to assist him, only the partial services of one clerk, class 2, Mr. E. A. Boeger. This gentleman has qualified himself as an expert in the inspection of instruments of precision and as such his services are invaluable, but the work of inspection is hampered and delayed by the multiplicity of his clerical duties which call for the preparation of the following papers, viz:

1. Requisitions for instruments and supplies of all kinds.
2. Inspection calls for all instruments and other supplies received.
3. Vouchers for payments of instruments, supplies, repairs, freight and express bills; together with the calculation and report of penalties incurred by contractors for late deliveries.
4. Invoices of all expenditures.
5. Bills of lading for all shipments by express or freight.
6. Reports of receipt of shipment orders, of shipments made and of shipments received.
7. Monthly reports of stock on hand.
8. Quarterly reports of receipts and expenditures, together with the accompanying abstracts of receipts and expenditures under both classes "A" and "B."
9. Quarterly reports of work done.
10. The posting of expenditure, receipt, and requisition books.
11. Together with the preparation of letters and indorsements, the frequent search of records for information desired by bureaus and individuals, the filing of certified bills, shipment orders, approved requisitions, notices of contracts awarded, and numerous other papers. He is, in fact, charged with all the clerical work, and must have the whole routine and business of the department at his fingers' ends.

A comparison of the table at the end of this report with those submitted in former reports will show the great increase of the work of this department over that of years preceding the large increase in the number of vessels in commission.

There are required immediately for the proper performance of the functions of this department in its rapidly increasing business:

First. The exclusive services of the present assistant.

Second. An additional clerk to assist in the inspection of instruments, preparation of papers, and keeping accounts.

Third. One stenographer and typewriter for the writing of letters, reports, indorsements, etc., and for the relief of both of the above from such clerical duties as may be possible, leaving them more time for the most important and engrossing work of inspection and test of nautical instruments.

The number of shipments made during the year was 338, amounting in value to $71,719.30.

The value of instruments received during the year was, by purchase, $58,727.40, and by return from navy-yards, etc., $38,605.66.

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The number of instruments received and issued during the year is shown in the following table:

Receipts and issues of nautical instruments.

Name.	Purchased.	Issued.
Artificial horizons	20	24
Azimuth circles	.....	1
Barometers, aneroid	88	85
Binoculars:		
Day	290	237
Night	370	296
Prismatic	59	50
Cameras, photographic	.....	2
Chains, surveyor's	.....	2
Chronometers:		
M. T. hack	2	26
M. T. standard	15	65
Clinometers	65	79
Clocks:		
Boat	175	69
Deck No. 1	260	76
Deck No. 2	143	93
Compasses, surveyor's	.....	1
Dip circles	.....	2
Dividers, navigator's	85	60
Drawing instruments (cases)	76	42
Heliographs	1	.....
Levels, surveyor's	.....	1
Magnetometers	.....	1
Octants	30	42
Parallel rulers:		
Sigsbee	60	9
24-inch	90	37
18-inch	105	56
15-inch	50	51
Photographic outfits	.....	2
Plane tables	.....	1
Protractors, three-arm	70	30
Psychrometers	81	33
Reading glasses, captain's	38	33
Sextants:		
High-grade	55	32
Squadron angle	.....	26
Surveying	130	51
Splines and weights, sets	50	28
Spyglasses:		
High-power	45	78
Low-power	80	88
Medium-power	15	67
Officer-of-the-deck	225	195
Tapes, steel:		
100-foot	60	27
300-foot	.....	3
Telescopes, large (on tripods)	2	5
Thermometers:		
Air	403	260
Maximum and minimum	2	41
Water	472	291
T-squares	50	40
Watches:		
Chronometer	.....	2
Comparing	53	41
Stop	35	36
Torpedo-boat	3	9

Very respectfully,

J. M. ROBINSON,
Commander, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

SIR: I beg to submit the following report of the work of this department for the fiscal year ending June 30, 1904:

Mr. H. R. Morgan, computer, remained on duty in the department for the first half of the year and was relieved on January 1, 1904, by Mr. C. N. Moore, computer, who remained in the department for the remainder of the year, after May 1 as a miscellaneous computer. I take pleasure in saying that both of these gentlemen rendered very intelligent and valuable services as soon as they became familiar with the special work on hand, and were indispensable in carrying on the work of the department.

RECOMMENDATION OF INCREASE OF FORCE.

I beg to repeat my previous recommendations that a permanent expert computer, at $1,600, be allowed to this department, because much of the time of a new computer detailed for the position is occupied in acquiring familiarity with all of the details of his duty. It would be economical, also, to have another assistant, at $1,400, with sufficient special technical training to clean and adjust clocks, watches, and at least hack chronometers. The saving of expense for such repairs in a year would, it is believed, more than pay his salary and at the same time enable the work to be done quicker and without any of the clerical work that is now necessary on the part of this Observatory and the Bureaus of Equipment and Supplies and Accounts in making requisitions, obtaining bids, awarding contracts, and forwarding articles back and forth by express. No private firm doing such a large and important business in this line would hesitate a moment in employing such an expert, and the necessity is still more vital here, in view of the emergencies of naval work in both peace and war.

SAVING OF TIME WITH INCREASED EFFICIENCY.

Every effort has been made, in view of the short-handed condition of the Observatory force, to adopt every possible expedient by which to save time without loss of accuracy, and in two instances this has resulted so favorably that they seem worthy of mention, as follows:

Inasmuch as the new Riefler clock in the clock vault was found to give excellent results, as used by the division of meridian instruments, I recommended that a wire be run from it to the chronograph in this department, in order that it might be used in connection with the other clocks of this department. With your approval this was done, and since November this fine clock has been available for our use, without even the necessity of ever walking over to get its face reading. Moreover, the regular star observations of the division of meridian instruments have been worked out promptly by the computer on duty in this department, thus saving the time and labor involved in the use of our own transit instrument, which is now available for other work.

A second and minor instance, but still of considerable importance in the saving of time daily, is a quick method that has been adopted of recording on the chronograph the comparisons of the many chronometers and watches that are under trial. Hitherto it has been done quickly by pressing an electric key at any ten-second reading of each

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chronometer, with an arbitrary signal to indicate which 10 the signal indicated, but at present it is done much more quickly by pressing the key at any five-second interval, a dash half a second long indicating 5, 15, 25, etc., and one second long, 10, 20, 30, etc. Then, in reading the chrongraph sheet, read units and tenths, adding 5 to the reading of the short dashes, and record the proper figure as shown by the regular weekly face comparison. In obtaining and recording data for 100 chronometers this method saves fully fifteen or twenty minutes a day, and is perfectly reliable.

The new forms that were prepared and printed last year for use in keeping chronometer records and deducing results of daily comparisons, trials, and performance at sea have also resulted in the saving of time and increased accuracy of results.

CHRONOMETERS WITH NICKEL-STEEL COMPENSATION.

In view of the experimental and apparently successful use abroad of marine chronometers with balances of nickel steel, or invar, a composition of wonderfully small coefficient of expansion, this department recommended that some be tried in our service. With your approval and that of the Bureau two chronometers of this kind were purchased (Nardin No. 115 and No. 120), subjected to an exhaustive trial at this Observatory, and are now undergoing a sea trial of three months on board of the U. S. S. *Hartford*. By thus keeping abreast of the times and utilizing whatever seems to promise improvement, it is hoped to serve the best interests of the Navy and of American commerce, as well as of American chronometer makers, who will doubtless watch the trial with great interest and profit by its results.

CHRONOMETERS FROM THE LOUISIANA PURCHASE EXPOSITION.

For reasons similar to those stated above it was suggested, in reply to inquiries from the Bureau relative to the cost and performance of foreign chronometers as compared with those made in this country, that the exposition at St. Louis furnished a good opportunity to enable us to put through the next regular chronometer trial at this Observatory a few of the best foreign marine chronometers on exhibition there, with a view to comparing them with our own. Arrangements have accordingly been made to do so, with the inducement held out to the various makers that some of their instruments would be purchased if they passed the trial well. Such action bids fair to add to our naval chronometers a number of the very best instruments of foreign make, and the results of the trial of all the various chronometers under identical conditions at this Observatory can not fail to be of great interest and value.

PROPOSED TRIAL OF TORPEDO-BOAT WATCHES.

It having become necessary to purchase more torpedo-boat watches for use in the service, a type of watch not yet manufactured in this country, it seemed desirable to notify the principal American watchmakers, as well as firms of established reputation abroad, in order that they might be given an opportunity to compete if they so desired. Specifications were accordingly prepared, approved by the Bureau,

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and sent to leading American and foreign firms. It is regretted, however, that as yet no American firms have accepted the invitation to compete.

It is understood, of course, that the manufacture of a new type of watch involves a large initial expense, and that the present purchase, even in its entirety, would by no means justify such an undertaking; and yet it would seem as though some enterprising firm might find in possible future sales for the use of the Navy, yachts, carriages, automobiles, railroads, and other sources of demand for a large, clear, accurate $100 watch, such a market as would justify the necessary plant. The proposed trial will be similar in all respects to the regular annual trial of chronometers, and take place at the same time, beginning in January next and ending the following June. The prices offered by the specifications range from $150 to $75, according to the results of the trial.

TRIAL OF NEW DECK CLOCKS, WATCHES, AND HACK CHRONOMETERS.

Much of the time of the department has been occupied with the trial of ordinary deck clocks, comparing watches, and stop watches, purchased from time to time as required and tested according to the various specifications issued by the Bureau. The following tabular statement will serve to indicate the amount of work of this kind that has been done, especially when it is remembered that the instruments come each in different lots, not all of a kind together, and that the periods of trial vary from one to three months, according to the type of timepiece:

Tried during the year:	
Deck clocks No. 1	194
Deck clocks No. 2	188
Boat clocks	109
Comparing watches	113
Stop watches	114
Hack chronometers	8

In addition to the above 6 torpedo-boat watches were tested under the old specifications, the trial lasting twelve weeks.

THE INSPECTION OF NAVIGATIONAL INSTRUMENTS.

As senior officer of the board of inspection it has been my duty to assist in the inspection of, and certify to the correctness of bills for, all the navigational instruments purchased, as well as of the many other articles that are required from time to time.

As regards the inspection of navigational instruments I take pleasure in expressing my appreciation of the invaluable assistance of Mr. E. A. Boeger, formerly a computer and now clerk class 2, whose long experience in such inspections has made his expert work and opinion of the greatest value, and who, by reason of my own absorption in my regular duties, has done practically all of the delicate expert work required by such inspection. In other inspections I have been materially assisted by Mr. G. H. Peters, photographer, Mr. William M. Gorman, captain of the watch, and other members of the Observatory force, according to the nature of the articles to be inspected.

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In this inspection alone there is, in my opinion, ample work to justify the detail of a line officer whose entire time could be occupied by it, to his own advantage as well as to that of the Observatory and the entire service, inasmuch as the thorough inspection of navigational instruments before issue is a matter of actual necessity.

TRANSIT INSTRUMENT REPAIRED.

Advantage has been taken of the present system of using in this department the Riefler clock and observations of the division of meridian instruments to send the 5-inch south transit instrument, which has been in constant use for many years and has long needed a thorough overhauling, to The Warner & Swasey Company, of Cleveland, Ohio, for repairs. When returned it is expected that it will be equal in all respects to a new instrument, and I understand that it is your intention to have it utilized in connection with some special line of work not directly connected with the work of this department. This change will be of undoubted advantage to the Observatory as a whole, both by preventing what has long been practical duplication of a part of the work and by enabling every instrument to be used to the best possible advantage.

TRIAL OF A NEW TYPE OF SHIP'S CHRONOMETER CHEST.

The board appointed by your order of February 8, 1904, to design a new type of ship's chronometer box or chest by reason of a complaint referred to this Observatory by the Bureau, consisting of myself as senior member, Mr. H. C. Cleve, instrument maker, and Mr. W. W. Dinwiddie, assistant in spectroscopic work, submitted a plan involving certain modifications of the type of wooden chest now in use. Not entirely satisfied with this plan, however, I have made further efforts, with your approval and that of the Bureau, to design and construct two different types of chest, with a view to (1) a better stowage of the chronometers as regards liability to rapid changes of temperature, (2) a better material as regards fireproof or at least slow-burning construction, and (3) a utilization of the ordinary or of an improved type of transporting case, which is now stored away and of no use during a vessel's entire cruise.

As a result of these efforts, involving considerable correspondence and experiment, two new types of chest have been constructed and have been sent on board of the U. S. S. *Hartford* for a practical trial at sea this summer in comparison with the old wooden type of chest already on board.

In requesting such sea trial the object was to adhere to the well established principle that it is of the greatest importance to test at sea under actual conditions on board of naval vessels every new type of equipment intended for such use. The report of this trial will naturally be given great weight in any future recommendation on the subject, involving, as it may, a possible change of type of chronometer chest for the entire service.

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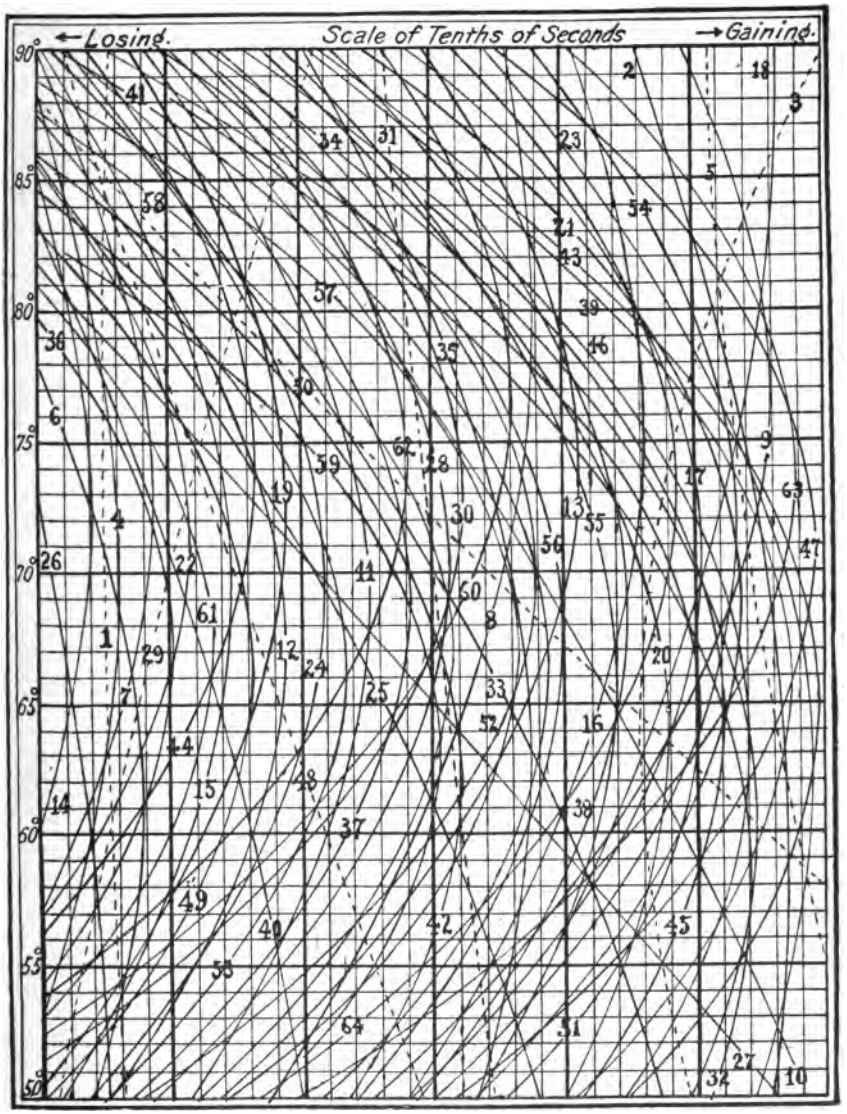
PLATE I.



TEMPERATURE RATE CURVES, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 14 TO JUNE 20, 1904.

The numbers are those of order of merit in the entire trial. The dotted curves indicate overcompensation.

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GRAPHIC REPRESENTATION OF THE FOUR QUANTITIES WHOSE SUM MAKES EACH TRIAL NUMBER, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 14 TO JUNE 20, 1904.

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REGULAR ANNUAL TRIAL OF CHRONOMETERS.

This trial began at noon, January 14, and ended at noon, June 20. It began with 42 new chronometers, subject to purchase after the trial, 60 old mean-time standards, 6 sidereal chronometers, 15 torpedo-boat watches, 6 chronometer watches, and 4 thermometric chronometers, a total of 112 chronometers and 21 watches, 133 in all. The temperature-room trial ended on April 8, and the chronometer-room trial on June 20. Some of the chronometers and watches were withdrawn for issue during the trial, most of these, however, late enough to allow of the calculation of an approximate trial number, but 81 chronometers and 17 watches completed the entire test.

The accompanying tabular statement of data gives the complete results for all those instruments for which trial numbers below 25 were obtained, and the results are gratifying both as to the number of new chronometers that passed and as to the good trial numbers obtained by the majority of old chronometers and watches.

With your approval and that of the Bureau, all of the old naval chronometers and watches that passed through this trial were surveyed and appraised with the new trial numbers as a basis of value, thus insuring that when issued they shall be invoiced at prices consistent with their present value for use in navigation. It is proposed to continue this plan hereafter, and thus do away with the old system of maintaining inconsistent book prices irrespective of actual changes in value.

Plate I shows graphically the rate curves of all the chronometers and watches that won a trial number below 25, and Plate II gives a graphic representation of the four quantities whose sum makes each trial number. These two plates are of especial interest in connection with similar plates published in my last two annual reports, and it is proposed to publish others in future reports, thus gradually completing what it is hoped will prove to be a useful graphic record of the trials, under the same conditions, of a large number of different makes and kinds of instruments.

THE TIME SERVICE.

The daily noon signals, now so useful and well known all over the country, have been continued regularly and with even greater accuracy than usual, the average error for the year being only fourteen-hundredths of a second, for the last six months thirteen-hundredths, and for the last three months nine-hundredths. This increased accuracy of the time service, while not materially important so far as the general public is concerned, which does not bother about a few hundredths of a second, indicates an improvement of real importance in connection with very delicate and accurate horological work, such as rating chronometers, telegraphic longitude determinations, etc., and it is of course the aim of this department to have the noon signals as nearly absolutely correct as possible. The least appreciable error of these signals, or of the fall of the time-balls dropped by them, enters directly into the latest determinations of the chronometer rates of ships on the eve of sailing, and such error accumulates daily as long as the voyage continues.

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NEW YEAR'S EVE TELEGRAPHIC TIME SIGNALS.

The plan commenced on New Year's eve, December 31, 1902, of sending out a series of telegraphic time signals at midnight, 1, 2, and 3 a. m., seventy-fifth meridian time, to announce the exact instant of the beginning of the new year to each of the great standard time belts of the United States, was repeated again this year, and with even greater success than before. The system of signals was exactly the same as that used daily at noon, as explained by the text and diagram accompanying my annual report for the fiscal year ending June 30, 1902. The series of signals, it may be repeated, begins at five minutes before the hour, includes each second of the clock except the twenty-ninth, the last five of each of the first four minutes, and the last ten of the last minute, after which long break there is a single long contact, the beginning of which marks the exact hour.

In order to secure as wide a distribution of the signals as possible, both as a matter of sentiment and in the interests of the universal adoption of accurate standard time, various telegraph and cable companies were notified of the plan, and most of them entered into it with great interest. Indeed, but for pressure of business on the part of the Eastern Extension and Australasia Telegraph Company, the signals might have been transmitted around the world. As it was, however, they reached as far as England, Australia, Alaska, and Argentina, thus covering nearly three-quarters of the civilized world and traversing about 300,000 miles of wire. Widespread newspaper comment showed general public appreciation of the signals, as transmitted by the Western Union, Postal, and American Telephone and Telegraph companies, and the extent of their distribution is illustrated by the fact that the Western Union Telegraph Company alone sent them through 186,173 miles of land lines within the United States, which probably leads the world in its appreciation of the value of accurate time.

The many reports received serve to give a slight, although of course incomplete, idea of the success with which the plan was carried out, and it should be remembered that it was done entirely by voluntary cooperation on the part of all concerned, whose willing and effective assistance is very highly appreciated. The signals were accurately timed at several observatories. They reached the Royal Observatory at Greenwich, England, in $1^s.33$; Lick Observatory, California, in $0^s.05$; the National Observatory of Mexico in $0^s.19$; Sydney Observatory, Australia, in $3^s.5$; and Wellington Observatory, New Zealand, in $4^s.0$. They where heard at Dawson, Skagway, Juneau, and Sitka, Alaska; at Panama, Valparaiso, and Buenos Ayres; at Honolulu, Guam, and Manila; and they traversed the cables beneath the Atlantic and Pacific oceans to announce to distant continents the exact instant of the beginning of the New Year in the United States.

OTHER SPECIAL TIME SIGNALS.

It seems manifest that it is for the best interests of this Observatory to encourage the sending out of such special time signals, especially whenever it can be done without expense or even any appreciable inconvenience. The standard clock and telegraphic connections being in daily use are always ready, and the sending of a special time signal

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involves but little more trouble than the turning of an electric switch. At the same time, every such signal adds its share to the popular appreciation of the work of the Observatory and to the increased knowledge and interest in the subject, both within and without the limits of the United States.

For this reason it is recommended that advantage be taken of important meetings in this city, such as that of the Eighth International Geographic Congress, to meet in September next, and the International Railway Congress, in May, 1905, to offer to send out to the world, as far as the telegraphs and cables will carry them, a special series of time signals, in celebration, as it were, of the meeting, and to invite to this Observatory such of the members as care to be present to see them go out. The two congresses referred to have, moreover, much more than a mere sentimental interest in the subject, as the universal adoption of standard time is a matter of great importance to geographers and railroad men, perhaps above all others.

THE PRESENT STATUS OF THE USE OF STANDARD TIME.

In view of the part that this Observatory has taken in the adoption of standard time in the United States, from which it has spread to many other countries, and of the numerous inquiries that are made to us on the subject, I recommend that an effort be made to collect and publish as complete data as possible regarding the kind of time in actual use in the various countries of the world. With your approval and that of the Bureau much information of this kind has already been collected.

Very respectfully,

EDWARD EVERETT HAYDEN,
Lieutenant-Commander, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

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1	76.07
	45
18	Apr. 25 to May 2.
5.	
11	−0.37
27	−0.36
36	−0.70
87	−3.21
01	−1.95
49	−2.36
13	−1.47
03	−0.36
93	+0.93
29	−0.03
19	−3.46
23	+0.46
16	−1.37
07	−0.1
79	−2.1
41	−0.4
23	−2.5
27	−0.6
14	+2.2
33	−0.
87	+1.
66	+2.
59	−0.
26	−1.
97	−3.
03	+0.
91	−1.
33	+0.
26	+1.
51	+2.
40	−0.
01	+0.
01	+4.
13	−1.
37	+0.
27	+1.
26	+0.
79	−1.
21	+0.
96	−1.
37	+3.
06	−1
29	−0
24	−1
26	−1
04	−0
76	+0
19	+0
23	−0
91	−0
24	+
27	+
59	+
73	−
20	+
29	−
26	−
71	+
96	+
54	−
06	−
31	−
86	+
80	+

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oom trial, mean daily rates. (Orientation changed for polarity test, one week on E., W., S., and N.)

1	76.07	78.11	74.78	72.00	74.60	73.62	72.88	70.58
	45	44	42	58	55	71	61	71
18	Apr. 25 to May 2.	May 2 to May 9.	May 9 to May 16.	May 16 to May 23.	May 23 to May 30.	May 30 to June 6.	June 6 to June 13.	June 13 to June 20.
11	−0.37	−0.37	−0.43	−0.26	−0.26	−0.31	−0.24	−0.01
27	−0.86	−0.24	−0.34	Issued to the Iowa.				
36	−0.70	−0.52	−0.74	Issued to the Atlanta.				
87	−3.21	−2.92	Issued to the Mayflower.					
01	−1.99	−2.07	−2.17	−2.09	−2.17	−2.24	−2.43	−2.47
49	−2.36	−2.24	−2.51	−2.60	−2.41	−2.47	−2.40	−2.40
13	−1.47	−1.40	−1.39	−1.34	−1.37	Issued to the Hartford.		
03	−0.30	−0.17	+0.19	+0.11	Issued to the Denver.			
93	+0.93	+0.88	+0.50	Issued to the Des Moines.				
29	−0.03	+0.14	−0.23	−0.43	−0.17	−0.30	−0.29	−0.31
19	−3.40	−3.34	Issued to the Mayflower.					
23	+0.40	+0.46	+0.34	Issued to the Atlanta.				
16	−1.37	−1.30	−1.47	−1.48	−1.46	−1.56	−1.47	−1.30
07	−0.19	−0.28	−0.28	Issued to the Olympia.				
79	−2.14	−1.81	−1.80	−1.89	Issued to the Illinois.			
41	−0.49	−0.37	−0.49	−0.97	Issued to the Dixie.			
23	−2.59	−2.50	−2.46	−2.54	−2.60	−2.50	−2.44	−2.51
27	−0.60	−0.67	−0.80	−0.83	−0.90	−0.90	−0.99	−0.80
14	+2.23	+2.61	+2.21	+2.11	+2.07	+2.49	+2.34	+2.44
33	−0.49	−0.13	−0.30	−0.34	−0.19	−0.11	−0.17	−0.37
87	+1.79	+2.01	+1.77	+1.77	+1.77	+1.79	+1.79	+1.77
66	+2.83	+3.03	+2.80	+2.46	+2.71	+2.51	+2.50	+2.60
59	−0.69	−0.46	−0.53	−0.73	−0.89	Issued to the Hartford.		
26	−1.33	−1.21	−1.50	−1.57	−1.44	−1.51	−1.61	−1.71
97	−3.93	−3.73	−4.13	−4.21	Issued to the Shubrick.			
03	+0.24	+0.19	+0.04	+0.39	−0.39	+0.66	+0.70	+0.73
91	−1.50	−1.23	−1.57	−2.11	−1.90	−1.91	−2.03	−2.14
33	+0.14	+0.33	+0.16	0.00	−0.09	−0.21	−0.23	−0.24
26	+1.93	+2.46	+2.20	+2.33	Issued to the Denver.			
51	+2.43	+2.54	+2.26	Issued to the Kearsarge				
40	−0.30	+0.16	−0.49	−0.64	−0.30	−0.50	−0.41	−0.27
01	+0.16	+0.41	+0.17	−0.26	−0.14	−0.21	−0.37	−0.39
01	+4.20	+4.57	+4.36	+4.04	+3.94	+3.89	+3.80	+3.44
13	−1.03	−0.84	−0.99	−1.10	−1.19	−1.29	−1.41	−1.30
37	+0.07	+0.31	+0.17	+0.03	−0.06	Issued to the Hartford.		
27	+1.40	+1.64	+1.16	+0.96	+1.14	Issued to the Chesapeake.		
26	+0.07	+0.20	+0.06	−0.29	−0.29	−0.37	−0.50	−0.64
79	−1.89	−1.70	−1.81	−1.86	−1.93	−2.00	−2.00	−2.13
21	+0.24	+0.49	+0.04	−0.07	+0.16	+0.27	+0.20	+0.03
96	−1.16	−0.91	−1.09	−1.40	−1.23	−1.19	−0.73	−0.67
37	+3.34	+3.47	+3.41	+3.21	+3.41	+3.33	+3.33	+3.30
06	−1.53	−1.18	−1.26	Issued to the Kearsarge.				
29	−0.27	−0.27	−0.39	−0.57	−0.14	−0.07	−0.13	−0.23
24	−1.50	−1.46	−1.44	−1.81	−2.06	Issued to the Hartford.		
26	−1.26	−0.80	−1.21	−1.50	−1.53	−1.60	−1.74	−1.63
04	−0.01	+0.07	+0.06	−0.31	+0.47	+0.34	+0.20	+0.04
76	+4.54	+4.83	+4.63	+4.56	+4.46	+4.37	+4.36	+4.16
19	+0.36	+0.61	+0.26	+0.14	+0.39	+0.30	+0.16	+0.07
23	−0.14	+0.12	−0.04	Issued to the Mayflower.				
91	−0.60	−0.21	−0.69	−1.34	−1.08	−1.01	−0.80	−1.07
24	+0.54	+0.70	+0.37	+0.13	+0.59	+0.49	+0.60	+0.46
27	+3.51	+3.27	+3.23	+2.94	+2.99	+2.69	+2.71	+2.96
59	+0.54	+0.74	+0.54	+0.43	+0.33	+0.29	+0.27	+0.14
73	−1.99	−1.91	−2.00	−2.27	−2.33	−2.24	−2.17	−2.16
20	+0.01	+0.09	−0.09	−0.21	−0.36	−0.44	−0.61	−0.70
29	−1.47	−1.36	−1.71	−2.04	−2.08	−2.13	−2.08	−2.11
26	−1.04	−0.90	−1.18	Issued to the Olympia.				
71	+0.66	+0.90	+0.79	+0.51	+0.60	+0.54	+0.54	+0.44
96	+1.99	+2.26	+2.16	+1.81	+2.03	+1.91	+1.99	+1.91
54	−0.99	−1.21	−1.40	−1.44	−1.39	−1.40	−1.24	−1.01
06	−0.14	+0.41	+0.36	+0.10	+0.14	−0.03	−0.34	−0.39
31	−0.27	−0.26	−0.60	Issued to the Alabama.				
86	+1.60	+1.74	+1.60	+1.44	+1.31	+1.34	+1.30	+1.31
80	+0.57	+0.63	+0.59	+0.33	+0.19	+0.04	−0.07	−0.11

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REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1905.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

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REPORT

OF

THE SUPERINTENDENT OF THE NAVAL OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 1, 1905.

SIR: I have the honor to submit this my annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1905:

PERSONNEL.

The following changes among the officers and employees have occurred since the last report:

Commander J. M. Robinson, U. S. Navy, was detached June 20, 1905.

Lieut. Commander T. D. Griffin, U. S. Navy, reported for duty June 7, 1905.

J. H. Root resigned as assistant April 21, 1905.

G. B. Merriman was promoted from assistant at $1,200 per annum to assistant at $1,400 per annum April 24, 1905.

Arthur Snow was promoted from assistant at $1,000 per annum to assistant at $1,200 per annum April 24, 1905.

H. B. Evans was transferred from assistant to piecework computer September 23, 1904.

A. B. Turner was transferred from computer to miscellaneous computer October 19, 1904.

C. W. Frederick was transferred from assistant on equatorial to assistant astronomer, Tutuila Observatory, naval station, Tutuila, Samoa, August 15, 1904.

E. D. Tillyer was promoted from assistant at $1,000 per annum to assistant at $1,200 per annum September 29, 1904.

W. W. Dinwiddie was promoted from assistant in spectroscopic work to computer October 19, 1904.

Matt Frederickson was transferred from miscellaneous computer to assistant on equatorial August 15, 1904, and was temporarily transferred from assistant on equatorial to miscellaneous computer June 13, 1905.

Arthur Newton was promoted from piecework computer to assistant at $1,000 per annum September 29, 1904.

Charles N. Moore was transferred from miscellaneous computer to assistant in spectroscopic work November 1, 1904.

L. G. Hoxton was appointed assistant on equatorial June 13, 1905.

Edwin C. Howell was appointed miscellaneous computer November 14, 1904, transferred to piecework computer January 21, 1905, and promoted to assistant at $1,000 per annum April 24, 1905.

Asaph Hall, jr., was appointed miscellaneous computer May 6, 1905.

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Benjamin Boss was appointed miscellaneous computer June 12, 1905.

J. L. Storla was appointed copyist August 3, 1904.

James H. Nelson was appointed messenger boy January 19, 1905.

Gustave Harrison was transferred from laborer to special laborer, Tutuila Observatory, naval station, Tutuila, Samoa, August 15, 1904.

John K. Throckmorton was appointed laborer July 1, 1904.

John S. Cheek was appointed laborer October 19, 1904.

V. Muehlhaus, jr., was transferred from laborer to watchman, Superintendent's office, State, War, and Navy building, March 13, 1905.

T. G. Wrenn resigned as fireman June 15, 1905.

G. S. Greenly was appointed fireman June 16, 1905.

PLAN OF WORK.

The general plan of the work has continued the same as noted in my last annual report, and is indicated in the following extract from an order issued at the beginning of the fiscal year.

Equatorials.—To make observations of the satellites of Mars, Jupiter, Saturn, Uranus, and Neptune when the planets are not more than three hours from the meridian; satellite work is to take the precedence of all other work; observations of occultations of stars by the Moon; observations of comets; photographic search for asteroids; and observations of double stars in intervals unoccupied.

Meridian instruments.—To make observations of the Sun, Mercury, and Venus at every culmination, except Sunday, whenever possible; of the Moon at every culmination, except between 8 a. m. and 5 p. m. on Sunday, whenever possible; of Mars, Jupiter, Saturn, Uranus, and Neptune, when in the vicinity of the Moon, to the extent of obtaining 30 observations of Mars and 15 each of Jupiter, Saturn, Uranus, and Neptune; of miscellaneous stars when requested; of a catalogue of 3,000 zodiacal stars; and when not interfering with the work above outlined, of stars from Newcomb's Suggested List of Fundamental Stars.

Prime vertical.—To make observations of four groups of stars, four stars in each group, α Lyræ and θ Aurigæ to be included by the polygon method.

Alt-azimuth.—To make observations of the stars of Newcomb's Suggested List of Fundamental Stars culminating here at zenith distances less than 75°.

Photoheliograph.—Daily photographs of the Sun, when possible, with temperature readings and scale settings, and preparation for future eclipse work.

ORGANIZATION.

The organization of the Observatory during the past year has been as follows:

OFFICE OF THE SUPERINTENDENT.

Clerk, Thomas Harrison; stenographer, Mrs. A. P. R. Auhagen.

ASTRONOMICAL BRANCH.

A. *Department of astronomical observations.*—Division of equatorial instruments (26-inch and 12-inch equatorials): Professor of Mathematics A. N. Skinner, in charge; Assistant Astronomer H. L. Rice, from July 15, 1904; Assistant Astronomer J. C. Hammond, Computer W. W. Dinwiddie, Assistant on Equatorial C. W. Frederick, to August 15, 1904; Assistant on Equatorial Matt Frederickson, from August 15, 1904.

Division of meridian instruments (9-inch and 6-inch transit circles): Professor of Mathematics W. S. Eichelberger, in charge; Assistant Astronomer H. L. Rice, to July 15, 1904; Computers W. M. Brown

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E. I. Yowell, H. R. Morgan, and A. B. Turner, to October 19, 1904; Miscellaneous Computer Asaph Hall, jr., from May 6, 1905.

Division of the alt-azimuth instrument: Professor of Mathematics F. B. Littell, in charge.

Division of the prime vertical transit instrument: Assistant Astronomer G. A. Hill, in charge.

The photoheliograph: Photographer G. H. Peters, in charge.

Librarian W. D. Horigan.

Computers for the department: Computer Eleanor A. Lamson and Miscellaneous Computers Etta M. Eaton, Alice M. Gray, Perez Fisch, Ella A. Merritt, from June 6, 1905, and Benjamin Boss, from June 12, 1905.

B. *Department of the Nautical Almanac.*—Professor of Mathematics Walter S. Harshman, director; Assistants H. B. Hedrick, W. Auhagen, J. Robertson, H. G. Hodgkins, J. H. Root, to April 21, 1905, G. B. Merriman, W. T. Carrigan, H. B. Evans, to September 23, 1904, E. D. Tillyer, A. Snow, A. Newton, from September 29, 1904, and E. C. Howell, from April 24, 1905, and Piecework Computers R. Buchanan, Mrs. E. B. Davis, A. Doolittle, Mrs. H. F. M. Hedrick, R. Keith, Janet McWilliam, T. I. King, A. Newton, to September 29, 1904, and E. C. Howell, from January 21, 1905, to April 24, 1905; Copyist J. L. Storla, from August 3, 1904.

NAUTICAL BRANCH.

A. *Department of nautical instruments.*—Commander J. M. Robinson, in charge to June 20, 1905, Lieut. Commander T. D. Griffin in charge from June 20, 1905; Clerk E. A. Boeger, acting assistant.

B. *Department of chronometers and time service.*—Lieut. Commander E. E. Hayden, in charge; Assistant in Spectroscopic Work C. N. Moore, acting assistant.

C. *Department of magnetism.*—Photographer G. H. Peters, temporarily in charge.

PUBLICATIONS.

During the fiscal year ending June 30, 1905, Volume IV, Appendixes II, III, and IV have been issued.

As showing the contributions to astronomy in general other than that shown in governmental publications, the following list of articles made public is submitted:

In the Proceedings of the United States Naval Institute, Vol. XXX, No. 2, "Work of the Naval Observatory," by Rear-Admiral C. M. Chester, U. S. Navy, Superintendent.

In the Astronomical Journal, No. 567: "Occultations of stars by the moon," by T. I. King and J. C. Hammond.

In the Astronomical Journal, No. 568: "Observations of minor planets and comet *a* 1904 (Brooks)," by J. C. Hammond.

In the Astronomical Journal, No. 569: "Ephemeris of comet *a* 1904 (Brooks)," by Herbert L. Rice.

In the Astronomical Journal, No. 571: "Elements and ephemeris of comet *e* 1904 (Borrelly)," and "Elements and ephemeris of comet *d* 1904 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson; Observations of minor planets," by W. W. Dinwiddie.

In the Astronomical Journal, No. 572: "Elements and ephemeris of comet *a* 1905 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson.

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In the Astronomical Journal, No. 574: "Observations of the satellite of Neptune at the opposition of 1904–5," by H. L. Rice and J. C. Hammond.

In the Astronomische Nachrichten, Nr. 3960: "Observations of a new asteroid, 1904 O F," by W. W. Dinwiddie; "Elements and ephemeris of a new asteroid, 1904 O F," by Eleanor A. Lamson.

In the Astronomische Nachrichten, Nr. 3989: "A photographic observation of a minor planet," by G. H. Peters.

In the Astronomische Nachrichten, Nr. 4026: "Observations of the satellites of Saturn and Uranus in 1904," by C. W. Frederick and J. C. Hammond.

In Popular Astronomy, March, 1905: "Elements and ephemeris of comet *d* 1904 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson.

In Popular Astronomy, May, 1905: "Elements and ephemeris of comet *a* 1905 (Giacobini)," by Eleanor A. Lamson.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

DIVISION OF EQUATORIAL INSTRUMENTS.

This division has continued under the successful management of Professor of Mathematics A. N. Skinner, U. S. Navy.

The distribution of the work of this division has been as follows: Professor Skinner, double stars; Mr. Rice, comets, asteroids, the satellites of Jupiter, Mars, and Neptune; Mr. Hammond, comets, asteroids, the satellites of Saturn and Neptune; Mr. Dinwiddie, asteroids; Mr. Frederickson, comets, occultations, the phenomena of Jupiter's satellites and asteroids.

During the latter part of the year Mr. Dinwiddie has been relieved of observing in order that he might devote his entire time to the eclipse preparations.

As heretofore, Mr. Peters has taken photographs with the 6-inch Dallmeyer camera for assisting in the identification of the fainter asteroids.

Professor Skinner continues to devote the most of his time to work in connection with the preparation of the catalogue of the Astronomische Gesellschaft Zone $-13^\circ\ 50'$ to $-18^\circ\ 10'$.

Observations have been made in this division during the year as follows:

38 asteroids	204
5 comets	100
Satellites of Mars	2
Satellites of Saturn	218
Satellites of Jupiter	150
Satellites of Uranus	27
Satellite of Neptune	17
Phenomena of Jupiter's satellites	53
Occultations	36
Double stars	67
Photographs for asteroids	49
Miscellaneous stars	13
Total	936

The tables of differential refraction for the latitude of the Naval Observatory, prepared by Mr. Frederick, have been published as

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Appendix III, Volume IV, Publications of the United States Naval Observatory, Second Series.

As in former years, the 12-inch equatorial has been devoted one evening a week and occasionally on other special evenings to afford a view of telescopic objects to persons admitted by permit to the Observatory. Mr. Peters was assigned to this duty, which he has performed most ably and acceptably until relieved on May 1 on account of pressing duties in connection with the eclipse expedition. The number of visitors received during the year has been 1,384 on 46 nights.

DIVISION OF MERIDIAN INSTRUMENTS.

This division has remained in charge of Professor of Mathematics W. S. Eichelberger, U. S. Navy, who, as secretary of the committee on editing and printing, also has had charge of the proof reading and the preparation of printer's copy of the department of astronomical observations and such reductions of observations and checking as can not be done in the division in which the observations are made.

As custodian of so much of the Observatory's records and as supervisor of their preparation his duties are most exacting. His administration of the division is highly commended.

The 9-inch transit circle.—This instrument has been devoted to the determination of the right ascensions and declinations of the sun, moon, planets, the stars of Newcomb's Suggested List of Fundamental Stars, and the stars of Gill's Catalogue of 2,798 Zodiacal Stars, with the addition of about 350 stars not in Gill's list in continuance of the plan outlined in the last annual report, which was put into operation on September 3, 1903.

The number of observations from July 1, 1904, to June 30, 1905, is as follows:

Zodiacal stars	3,917
Standard stars	3,919
Screen stars for personal equation	462
Zenith stars for personal equation	293
Astronomische Gesellschaft Zone zero stars	22
Astronomische Gesellschaft Zone zone stars	6
Sun	174
Moon	125
Mercury	57
Venus	114
Mars	30
Jupiter	17
Saturn	15
Uranus	13
Neptune	15
Total	9,179

The number of observers regularly employed during more than half of the year under consideration has been one less than during the preceding year.

Five of the circle microscopes were provided with new objectives by the J. A. Brashear Company (Limited) in May, 1905, as the definition of the old objectives was not good.

Several series of observations by the different observers to determine their personal equations depending on the magnitude of a star by the use of wire-gauze screens were made in April and May, 1905.

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A comparison of these results with similar ones determined a year previous indicates that the personal equation due to a change of 2½ magnitudes in the brightness of a star has increased about 0ˢ.01 in two cases and decreased about 0ˢ.01 in one case.

Since September, 1903, nine determinations by the use of horizontal collimators of the correction to be applied to observed zenith distances have been made, and the results arranged chronologically are −1″.09, −1″.13, −1″.20, −1″.30, −1″.20, −1″.35, −1″.43, −0″.85, and −1″.13.

The reductions of the observations made with this instrument are getting more and more in arrears for lack of sufficient computing force.

The 6-inch transit circle.—No determinations of position have been made with this instrument during the year.

A discussion of Assistant Astronomer Hammond of about 1,500 observations made by Professor Updegraff and himself in 1901–2 gives the probable error of the mean of four microscopes due to division error 0″.36 for Circle A and 0″.29 for Circle B. A discussion by Professor Littell of the observations made in connection with the sun, moon, and planet work gives probable errors of about the same size. These results were obtained with the circles regraduated by The Warner & Swasey Company in 1901, and are somewhat larger than those obtained by Professor Updegraff from the original graduations.

An order has been given to The Warner & Swasey Company, of Cleveland, Ohio, for the construction of a self-registering micrometer of the Repsold type for use with this instrument.

All the observations made with this instrument have been reduced and will appear in the next volume of the Observatory's publications issued from the press.

The standard sidereal clock.—The new sidereal clock, Riefler No. 70, which was sent back to the maker in June, 1904, that the difficulties spoken of in the last report might be corrected, was returned in September, 1904. It has been constantly in use since October 11, and has given perfect satisfaction. From November 20, 1904, to February 2, 1905, assuming the daily clock rate to be −0ˢ.1648−0ˢ.00064 (t–Dec. 27.0) the mean residual from a comparison of the observed and the computed clock corrections is 0ˢ.04. From February 7 to April 16, assuming the daily clock rate to be −0ˢ.0062 + 0ˢ.00063 (t–Mar. 13.0), the mean residual is also 0ˢ.04.

During the first period the temperature in the clock vault increased gradually about 1° C., while in the second period the temperature decreased gradually about 2° C.

The rates given were obtained by a least square solution of about twenty clock corrections in each group. The barometric pressure in the clock case was changed between the two periods.

General reductions.—The stars, which were omitted from the original observing list of the Astronomische Gesellschaft Zone Catalogue −13° 50′ to −18° 10′ by mistake, have been observed during the present year. Otherwise all the observations of this zone are reduced to 1900.0, and the precessions and secular variations have been computed for the same epoch. All the stars in Bessel's Zones, in Lalande's Histoire Céleste, in Argelander's Southern Zones, and in the Münchener Sternverzeichniss I and II, and also in the Astronomische Gesellschaft

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Zone have been reduced to 1900.0 for purposes of comparison. This work is being carried on under the direction of Professor Skinner, and most of it is being done by him personally.

Since the last report the preliminary revision of the transit instrument zones of the Washington Zone Catalogue has been completed, and the comparison of the zones with the Cordoba General Catalogue has been finished. The same work has been done also for the first year of the meridian circle zones. The zone corrections have been computed for and applied to about nine-tenths of the mural zones. The reduction of the 3,500 unpublished zone observations made with the meridian circle in 1847–48 is about finished. This work is being carried on under the direction of Professor Littell.

Since the last report three appendixes of Volume IV, Publications of the United States Naval Observatory, Second Series, have been published. Appendix II, Reduction Tables for Transit Circle Observations, pages 54; Appendix III, Reduction Tables for Equatorial Observations, pages 101; and Appendix IV, The Present Status of the Use of Standard Time, pages 28. Appendix I, Total Solar Eclipses of May 28, 1900, and May 17, 1901, is at the Printing Office.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

This division has been under the charge of Professor of Mathematics F. B. Littell, U. S. Navy, whose official management of it is commended. The determination of the declinations of the stars of Newcomb's Suggested List of Fundamental Stars which culminate here at zenith distances less than 75° has continued as before. The observing list comprises 1,186 stars at the upper and 136 stars at the lower culmination. A few other stars culminating very near the zenith have also been added to the observing list. The number of observations secured during the year is 1,896. Each complete observation furnishes a double zenith distance of the star observed. Readings are made on two circle divisions under each of the microscopes and two alidade levels are used. The observations and their reductions are progressing satisfactorily.

The system of illumination of the microscopes has been changed and made similar to that in use for several years on the 9-inch transit circle. The original system was by central lamp illumination, the light being conducted to each of the four microscopes by a train of mirrors. For this has been substituted a small 3½-volt electric lamp for each microscope operated by battery current. Each lamp is in use only while the microscope is being set, the circuit being closed by a push button pressed by the foot of the observer. The tube which holds the lamp at one end is arranged at the other end to protect the portion of the circle under the microscope from extraneous light, so that in daylight the same illumination is obtained as at night.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

With the prime vertical instrument Assistant Astronomer G. A. Hill has continued the polygon method of observing. Two changes in the observation of α Lyræ as now used are believed to be advantageous to the work. The first of these is to secure at each culmination of the

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star transits by direct pointing at the heavens, and also by reflection from a basin of mercury placed upon the floor. The other is to reduce, in the night-time, the brightness of the star's image by means of a wire-gauze screen placed in front of the object glass, giving it the appearance of a sixth magnitude star instead of one of the first magnitude.

Mr. Hill's long and efficient management of this instrument and the large number of observations made by him give him a marked leadership in the use of a prime vertical transit instrument, and astronomers may well expect a most useful addition to astronomical records when the series of observations, which it is hoped will extend through at least one revolution of the moon's node, is published.

The number of observations made during the year is 625.

THE PHOTOHELIOGRAPH.

During the year the sun has been photographed with this instrument on one hundred and sixty-six days and solar spots and faculæ were found on the plates on one hundred and sixty-two days.

While there has been a decrease in the number of photographs secured during this year as compared with the previous one, owing to the unusual amount of cloudiness which has prevailed, Photographer George H. Peters, who has had charge of the instrument, has added a valuable number of observations to the record. The series of photographs secured during several years past gives, with a constantly increasing accuracy, the value of the focal variation due to temperature. The perfection of the solar image upon the photographic plate depends largely upon the atmospheric conditions.

Two enormous groups of solar spots have appeared during the year, and many other large and important groups have been observed in the same period.

The new triple lens of 7½ inches aperture and 65 feet focal length, mentioned in the last report, was received from its makers, the John A. Brashear Company (Limited) of Allegheny, Pa., in April. It was mounted for testing with a view to its use in Spain during the approaching total solar eclipse. Upon the return of the expedition it is intended to mount it to be employed in the daily photographic work on the sun.

The new lens gives an image of the sun's disk about 7 inches in diameter instead of 4¼ inches, as in the photoheliograph at present in use.

Mr. G. F. Coulon has ably assisted Mr. Peters during the past year, and is highly commended by him. During the absence of Mr. Peters from the Observatory on the coming eclipse expedition Mr. Coulon will have temporary charge of the instrument, and thus a complete series of solar photographs will be obtained to be used in connection with the eclipse observations. This is a very important factor, as many coronal features observed at total solar eclipses have an intimate relation with sun spots and faculæ.

LIBRARY.

The library has continued under the successful administration of Librarian W. D. Horigan.

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The cataloguing of the library is progressing and with the exception of the serials devoted exclusively to meteorological and magnetic observations the author catalogue is now completed.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1904	19,276	4,133	23,409
Accessions	420	70	490
Contents July 1, 1905	19,696	4,203	23,899

Of the accessions, 257 were received as exchanges and 233 were purchased.

DEPARTMENT OF THE NAUTICAL ALMANAC.

This department has continued under the direction of Professor of Mathematics W. S. Harshman, U. S. Navy.

There have been received during the year from the Government Printing Office 1,000 copies of the first edition of the American Ephemeris and Nautical Almanac for 1908, 2,300 copies of the second edition of the American Nautical Almanac for 1905, 1,731 copies of the Pacific Coaster's Nautical Almanac for 1905, 702 copies of the second edition of the American Ephemeris and Nautical Almanac for 1905, and 153 copies of the American Ephemeris and Nautical Almanac for 1904.

During the present fiscal year the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris	766	884	1,650
American Nautical Almanac	2,540	352	2,892
Atlantic and Pacific Coaster's Nautical Almanac	1,451	26	1,477
Astronomical Papers	54	39	93

The proceeds of the sales, amounting to $1,778.90, have been deposited with the Treasurer of the United States to the credit of public printing.

The current work of this department is up to date.

As a result of the recent legislation of Congress, the number of copies of the American Ephemeris provided by law to be supplied to the Navy Department for sale and distribution is inadequate to meet the demands. It has therefore been necessary to supply this deficiency by a requisition upon funds of the Navy Department, although it is specifically provided by law that the proceeds of the sales of these copies shall be deposited to the credit of the general printing fund. It is recommended that legislation be secured for the printing of the full number of copies needed for sale and distribution.

All copy for the Zodiacal Catalogue is in plate, and the volume will be issued as soon as received from the Government Printing Office.

Attention is invited to the fact that, on account of the high scientific attainments required of the assistants in this department, appropriate legislation should be recommended making suitable increase in salaries.

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DEPARTMENT OF NAUTICAL INSTRUMENTS.

This department has remained under the efficient charge of Commander J. M. Robinson, U. S. Navy, until June 20, 1905, when his services were required for other duty, much to my regret.

The supply of nautical instruments to ships in commission, or about to be commissioned, to navy-yards and shore stations, wireless telegraph stations, and the naval militia of the various States has proceeded regularly and promptly in accordance with shipment orders received. In addition two complete surveying outfits have been issued, and this department is now engaged in assembling two new surveying outfits to replace the two issued. Owing to the great pressure of routine work, this undertaking is proceeding very slowly.

The stock of nautical instruments has been kept up to the authorized amount by the acquisition of additional instruments on requisitions, which instruments have been inspected, tested, and stored as received.

The clerical work involved in keeping the fleet supplied with nautical instruments is very heavy, is increasing rapidly, and is already more than one man can accomplish alone. In consequence the officer in charge has constantly to devote the major part of his time to the preparation of routine papers to the exclusion of work of a more important character, such as the study of nautical and surveying instruments and their suggested improvements. I beg to invite your attention again to the urgent need of increased expert and clerical assistance in this department of the Observatory, the work of which is increasing with the growth of the fleet to such an extent that it is impossible with the present force to devote that time and attention to the inspection of nautical and surveying instruments which instruments of such a character demand.

There is constantly in stock at the Observatory in the instrument room, in the chronometer room, and in the storeroom approximately $100,000 worth of instruments. The officer in charge of this department is responsible for these instruments and has as a care taker or storekeeper only a laborer detailed for that purpose who is also charged with the work of packing and shipping all instruments issued and unpacking and storing those received. The laborer detailed for this work, Mr. John Brockman, is eminently qualified therefor. He is careful, thorough, methodical, and reliable, and his services are of great value in this department.

During the year considerable correspondence has been carried on with several of the American makers of optical instruments in an effort to induce them to take up the manufacture of binoculars and spyglasses for marine use in the hope of securing a better class of these instruments than is at present supplied by the importers. The greatest difficulty with which the American manufacturers of optical instruments have to contend is the cost of production, due to the high price of labor. The difference in cost, however, in favor of the foreign maker becomes less as the character of the work improves, and it is believed that by demanding optical instruments of the highest class and finest finish the American manufacturers will be encouraged to compete with the foreign maker. In the manufacture of prismatic binoculars two American firms are already competing successfully with the foreign makers.

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The number of shipments made during the year was 395, amounting in value to $99,146.80.

The value of instruments received during the year was, by purchase, $23,675.09, and by return from navy-yards, etc., $44,688.76.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department has remained in charge of Lieut. Commander E. E. Hayden, U. S. Navy, assisted by Mr. C. N. Moore.

The routine work, consisting of the trial, care, and rating of naval chronometers, watches, and clocks, their issue, with the necessary data and forms, to naval vessels, the supervision of their repairs, and the sending out of the daily telegraphic noon signals, has been carried on very successfully in spite of the small available office force and the increasing demands of the Navy.

The regular annual chronometer trial began in January with 40 new chronometers, 31 new torpedo-boat watches, 84 old chronometers, 5 old torpedo-boat watches, and 1 old chronometer watch. This trial consisted of three separate trials, but all went on together for six months—three months in the temperature room and three months in the chronometer room—in accordance with the terms of the Bureau's specifications No. 25 of May 15, 1903, and No. 269 of February 26, 1904. There were also on hand at the beginning of the trial 28 other chronometers and watches, making in all 189 chronometers and watches that were wound and compared daily, their rates being computed, recorded, and plotted weekly.

The results of the three trials are given in the appended tables, trial numbers above 25 being omitted:

TABLE I.—Trial of new American chronometers with steel hair springs and ordinary balances.

TABLE II.—Trial of new torpedo-boat watches.

TABLE III.—Trial of old naval chronometers.

The amount of careful expert work involved in connection with this trial will be better appreciated when it is remembered that the Superintendent of this Observatory in 1886 stated in an official report (Appendix III to Washington Observations for 1883) that "the example of the computation of a trial number given will serve to give some idea of the amount of labor involved in this test of more than 50 chronometers; when to this are added the voluminous records necessarily kept it will be seen that this duty involves no light work." It need only be added that there are at present three times the number of chronometers and only two-thirds as large an office force in this department of the Observatory. Its increased efficiency has resulted largely from improved methods devised by the officer now in charge.

The accuracy of the time service has now become almost perfect, the maximum error of the daily noon signals for the month of April, for instance, having been only $0^s.06$ and the mean daily error for that month only $0^s.017$, the best monthly record ever made at this Observatory.

The usual special series of midnight New Year's eve telegraphic time signals were sent out, and two other special series of midnight signals, the first on September 8 in honor of the International Geographic Congress, and the second on May 3 in honor of the International Railway Congress. All of these special series of time signals were transmitted

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far and wide through the voluntary cooperation of various telegraph, cable, and telephone companies, and excited international interest and attention. Their effect, based as they are upon Greenwich standard time and enlisting, as they do, the assistance of governments, companies, and observatories all over the world, is thought to add a powerful influence toward the universal adoption of Greenwich standard time and longitude.

The following reports of the time of transmission of these special time signals, selected from among the many received, will serve to illustrate their accuracy and rapidity in spite of the relays and manual repetitions that are necessary on very long lines.

Quickest reported times of transmission of time signals from the Naval Observatory.

Locality.	Time of transmission.
	s.
McGill College Observatory, Canada	0.00
Toronto Observatory, Canada	0.00
Santa Clara College Observatory, California	0.04
Lick Observatory, California	0.05
Chamberlin Observatory, Colorado	0.07
Ladd Observatory, Rhode Island	0.07
Washburn Observatory, Wisconsin	0.09
Amherst College Observatory, Massachusetts	0.10
Chabot Observatory, California	0.10
Goodsell Observatory, Minnesota	0.10
Harvard College Observatory, Massachusetts	0.10
St. John Observatory, New Brunswick	0.11
Tacubaya Observatory, Mexico	0.11
Coast and Geodetic Survey station, Seattle, Wash	0.29
Manila Observatory, Philippine Islands	0.37
Mare Island Observatory, California	0.37
Roman College Observatory, Italy	1.10
Greenwich Observatory, England	1.33
Hamburg Observatory, Germany	1.47
Coast and Geodetic Survey station, Alaska	1.70
Sydney Observatory, Australia	2.25
Survey Office, Brisbane, Australia	2.45
Adelaide Observatory, Australia	2.96
Wellington Observatory, New Zealand	4.00
Cordoba Observatory, Argentina	7.70

The special midnight time signals sent out on May 3 were displayed very effectively by means of a very large map of the world, 21 by 42 feet, erected on the grounds of the Railway Appliance Exhibit, near the Washington Monument, with small electric lights arranged to mark the exact positions of more than 200 of the principal cities of the world. The lights in the United States were illuminated each second by our standard clock and the final midnight signal was made to spread rapidly over the world, exactly as actual reports have indicated. The Secretary of the Navy turned on the current at five minutes of 12, and the large audience that was present watched the demonstration with the greatest interest. The same map was used in a similar way at 8, 9, and 10 p. m. on several subsequent evenings, and proved to be one of the most attractive features of the exhibit.

On March 11, a new time-ball went into operation at Pittsburg, Pa., making 19 in all in the United States. This new time-ball was installed by the Farmers' Deposit National Bank on the roof of their 24-story building, and is operated with the cooperation of this Observatory, the Western Union Telegraph Company, and the United States Weather Bureau. Its elevated location, 400 feet above the

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ground, which enables it to be seen from all parts of the city and from the adjacent rivers and surrounding country, will undoubtedly serve to make it very useful to business men and inland commerce generally.

Three copper-covered, asbestos-lined chests, each fitted to take three chronometers in their boxes and transporting cases, have been made for trial during the eclipse expedition and, if approved, for subsequent use at sea. The advantage of such chests over the chests now in use is that, while no larger than the latter, they allow of the constant use of the ordinary chronometer-transporting cases for the increased protection of the chronometers, and are of practically fireproof construction. For convenience and safety in carrying chronometers to and from the Observatory, a special padded leather carrying case or valise has been added to the equipment of this department, in which nine chronometers, each in a corrugated paper box, can be carried with very little liability to injury or of disturbance of their rates.

A monograph on the "Present Status of the Use of Standard Time" was prepared by Lieutenant Commander Hayden and published as Appendix IV, Volume IV, of the Publications of the Observatory. This publication contains official data regarding the kinds of time in actual use by all of the principal nations of the world, collected for this Observatory by the Department of State through the diplomatic and consular service and the Office of Naval Intelligence, Bureau of Navigation, through the naval attachés, together with tables for the ready conversion of the time of one country into that of another.

BRANCH OBSERVATORY AT TUTUILA, SAMOA.

Mr. C. W. Frederick, assistant on equatorial at the Observatory, was appointed an assistant astronomer, naval station, Tutuila, Samoa, on July 18, 1904, and Mr. Gustave Harrison, laborer, was at the same time appointed care taker. They were ordered by the Department to proceed from San Francisco on September 8, to Tutuila, and report to the commandant at that station for the purpose of erecting an astronomical observatory. They arrived at Tutuila on September 21.

Upon recommendation from the Superintendent the Department authorized the purchase of the necessary material for the construction of the transit circle house, the clock house and observer's office, and dwellings for the observer and his assistant.

Mr. Frederick has submitted reports to the commandant, naval station, Tutuila, which have been referred to the Superintendent of the Naval Observatory, giving the course of construction. In a report recently submitted he states that the transit circle house and the clock house, which is to be one in which a constant temperature can be obtained, are practically completed together with the necessary piers, and that he was ready to mount the instruments. It is thought that astronomical observations will soon be begun, furnishing data which is much needed covering a zone from the south pole to beyond the zenith of Washington.

BUILDINGS.

The buildings belonging to the Government within the Naval Observatory Reservation are in generally good condition, but owing to the fact that the transit houses are of iron construction, from which paint peels off in warm weather, it will soon be necessary to give them another coating of that material to keep them from serious deterioration.

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MACHINE SHOP.

Last year there was installed a small machine shop at practically no expense, as for its equipment there was used condemned material collected from various navy-yards. During the present year the great usefulness of this shop has been shown and the desirability of its further development has become apparent. Mr. W. W. Dinwiddie, computer, was placed in charge of the shop, and with the assistance of Mr. H. C. Cleve, instrument maker, has constructed there many of the instruments for observing the solar eclipse of August next. Had it not been possible to do this work in the shop it would have taken nearly the whole eclipse appropriation to have secured the instrumental equipment necessary.

I hope in the future to be able to take up the question of enlarging the shop, as experience has demonstrated that it will lessen the expenses for repairs and construction of instruments, as well as permit more prompt attention to such work than can be had when dependence is placed upon instrument makers in other cities.

I wish to record here my appreciation of the services of Mr. Dinwiddie, who has been chiefly concerned with the development of this work, and to whose industry and skill in construction the completeness of the eclipse instrumental equipment is due. As showing what has been done in this respect I feel warranted in quoting from a letter recently received by the Superintendent from the manager of one of the largest instrument works of the country, whose reputation is world-wide, as follows:

> I had the pleasure of looking over your apparatus (preparing for observing the eclipse of the sun on August 30, 1905), with which I was much impressed, as it seemed to me particularly well designed and very efficient.

PHOTOGRAPHIC EQUATORIAL.

During the year Mr. Dinwiddie has taken from the scrap heap of old iron the mounting formerly used for the 26-inch equatorial at the old Observatory and fitted it up with the framework of an obsolete 9-inch telescope, which is to carry two Dallmeyer lenses for photographing asteroids. Over this there has been constructed a house designed and largely built by him which will answer all purposes for carrying on this important branch of astronomical work. It is thought this plant will compare favorably with any other that could be duplicated for $10,000 or $15,000. As soon as the Observatory force is relieved from the duty of making preparations for and of observing the next solar eclipse, it is expected that good results will accrue from this plant.

GROUNDS AND ROADS.

I have to renew the recommendation contained in my last annual report that early steps be taken to acquire the property lying within the Observatory Circle, as contemplated by the joint resolution of Congress approved August 1, 1894. The question of the transfer of the tract of land belonging to Mr. Philip Young and of that belonging to the Normanstone estate still remains in the District courts, and will probably be settled by the time it is necessary to get the ground in shape to harmonize with the other public property. The property belonging to the District of Columbia, known as the Industrial Home

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TABLE I.—*Tabular statement of data of competitive trial*

Temperature, by thermometric chronometers.....degre

Relative humidity, by sling psychrometer.....per c

Order of merit.	Balance: o=ordinary. a=auxiliary. c=corrector. v=invar.	Hairspring: s=steel. p=palladium. l=alloy, composition unknown.		Trial number.	Point of compensation		
					Temperature.	Rate.	Temperature sta
					°	s.	
1	Bond	517	o. s.	11.91	66.9	+0.24	+0.
2	.....do	526	o. s.	12.26	69.8	−0.56	+0.
3	Negus	2050	o. s.	12.89	68.1	−0.75	+0.
4	Bond	574	o. s.	18.75	59.6	+0.53	+0.
5	Negus, M. T. B. C.	2045	o. s.	18.79	63.5	+2.63	+0.
6	Negus	2054	o. s.	20.96	67.9	−0.48	+0.
7	Negus, M. T. B. C.	2046	o. s.	21.93	72.1	+1.39	+0.
8	Bond, M. T. B. C.	452	o. s.	22.39	70.5	−0.35	+0.
9	Negus, S. B. C.	1928	o. s.	22.43	65.9	+1.31	+0.
10	Negus	2042	o. s.	25.24	68.8	−0.14	+0.
11	Bond	608	o. s.	25.35	66.3	+1.01	+0.

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.....per c

compensatio

Rate.	Tem ture sta
s.	
+0.24	+0.
-0.56	+0.
-0.75	+0.
-0.53	+0.
-2.63	+0.
-0.48	+0.
-1.39	+0.
-0.35	+0.
-1.31	+0.
0.14	+0.
1.01	+0.

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TABLE II.—*Tabular statement of data of competitive trial*

Temperature, by thermometric chronometers.....degrees

Relative humidity, by sling psychrometer.....per cent

Order of merit.	Balance: o=ordinary. a=auxiliary. c=corrector. v=invar.	Hairspring: s=steel. p=palladium. l=alloy, composition unknown.		Trial number.	Point of compensation: Temperature.	Point of compensation: Rate.	Temperature sta
					°	*s.*	*s*
1	Nardin	10977	v. s.	5.45	83.5	−1.25	−.
2	.....do	10811	v. s.	7.75	58.3	−1.95	−.
3	.....do	10669	v. s.	12.65	126.0	+0.27	−.
4	.....do	10972	v. s.	13.84	64.9	−1.85	+.
5	.....do	10976	v. s.	15.75	73.1	+1.73	−.
6	.....do	10974	v. s.	16.86	73.6	−2.70	−.
7	.....do	10807	v. s.	20.07	62.3	−0.63	+.
8	Patek, Philippe & Co...	119091	o. s.	21.30	78.2	−4.31	+.
9	.....do	119093	o. s.	23.58	80.6	−3.66	+.

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ta of trial of old naval chronometers, United States Naval Observatory.

OTE.—The signs are astronomical, + losing; − gaining. Data of chronometers with trial number gre

Temperature-room trial, mean daily rates. (Orientation of chronometers not changed.)

F..	89.68	84.68	69.36	55.10	49.79	50.45	55.10	69.84	85.28	90.4
nt...	50	52	42	49	57	60	60	55	58	52
era-on-t.	Jan. 5 to Jan. 12.	Jan. 14 to Jan. 21.	Jan. 23 to Jan. 30.	Feb. 1 to Feb. 8.	Feb. 10 to Feb. 17.	Feb. 17 to Feb. 24.	Feb. 27 to Mar. 6.	Mar. 8 to Mar. 15.	Mar. 17 to Mar. 24.	Mar. to Apr.
0083	−0.88	−0.96	−0.97	−0.57	−0.37	−0.37	−0.70	−1.03	−1.03	−1.
0013	+0.35	+0.01	0.00	+0.30	+0.37	+0.36	+0.39	+0.30	+0.01	−0.
0005	−0.12	−0.39	−1.00	−1.50	−1.64	−1.53	−1.49	−0.99	−0.59	−0.
0100	−0.06	−0.31	0.00	+0.73	+0.73	+0.79	+0.50	−0.11	−0.34	−0.
0176	+1.55	+0.80	+0.16	+0.40	+0.94	+1.06	+0.63	+0.47	+1.04	+1.
0152	−0.56	−0.34	−0.61	−0.10	+0.69	+0.76	+0.30	−0.46	−0.69	−0.
0173	.....	+1.36	+0.69	+0.59	+0.91	+0.96	+0.71	+0.37	+1.04	+1
0289	+1.79	+1.36	+0.71	+1.46	+2.14	+2.19	+1.59	+0.84	+1.27	+1
0101	−0.24	−0.30	−0.43	+0.40	+0.14	+0.21	+0.27	+0.01	−0.36	−0
0067	+0.11	+0.23	+0.39	+0.14	+0.01	+0.11	−0.14	+0.21	+0.39	+0
0285	+0.31	−0.13	−1.06	−0.64	−0.31	−0.39	−0.84	−1.09	−0.13	+0
0071	−1.48	−1.57	−1.86	−1.86	−1.84	−1.74	−2.33	−2.49	−2.30	−1
0289	+1.52	+1.21	+0.73	+1.37	+1.74	+1.59	+1.16	+0.49	+1.29	+1
0034	+2.11	+1.64	+1.39	+1.24	+0.70	+0.71	+0.46	+1.14	+1.44	+1
0092	+1.21	+1.10	+0.24	+0.14	−0.10	+0.11	+0.29	+0.70	+1.21	+1
0265	+0.71	+0.21	−0.77	−0.87	−0.40	−0.17	−0.57	−1.03	+0.04	+0
0236	+2.54	+2.26	+1.89	+2.34	+2.41	+2.24	+1.74	+1.30	+2.17	+2
0313	−0.86	−1.11	−1.56	−0.56	+0.26	+0.19	−0.56	−1.59	−1.33	−0
0259	+3.36	+2.73	+1.79	+1.99	+2.20	+2.17	+1.69	+1.47	+2.46	+2
0096	−1.49	−1.24	−0.41	−0.44	−1.26	−1.39	−1.33	−1.26	−1.23	−0
0353	+0.79	+0.43	−0.46	+0.16	+0.97	+1.07	+0.43	−0.43	+0.37	+0
0240	+1.11	+0.77	+0.56	+1.27	+1.60	+1.67	+0.71	+0.04	+0.57	+1
0306	+3.99	+3.36	+2.11	+2.34	+2.44	+2.53	+2.07	+2.00	+3.24	+2
0277	+0.95	+0.21	−1.26	−1.21	−0.74	−0.66	−0.94	−0.77	+0.43	+.
0261	+1.36	+0.94	−0.27	−0.37	−0.04	+0.16	−0.06	−0.27	+0.81	+.
0183	+1.71	+1.50	+1.23	+2.53	+2.87	+2.80	+1.96	+1.86	+1.77	+2.
0336	+1.58	+1.00	−0.33	+0.14	+0.53	+0.40	+0.20	+0.09	+1.24	+1.
0268	−0.06	−0.96	−2.77	−3.03	−2.93	−2.80	−2.89	−2.29	−0.71	+0.
0345	+0.49	+0.21	+0.01	+1.09	+1.53	+1.51	+0.67	−0.44	+0.20	+0.
0060	−0.56	−0.37	−0.47	−0.49	−0.99	−0.63	−0.27	−0.79	−0.87	−1.
0351	+2.58	+2.30	+1.23	+1.39	+1.81	+1.79	+1.44	+1.10	+2.70	+3.
0401	+1.01	+0.37	−0.76	−0.43	+0.53	+0.47	+0.10	−1.10	−0.16	+0.
0167	+1.38	+0.94	−0.64	−1.36	−1.70	−1.53	−1.26	−0.73	+0.59	+0.
0232	−1.92	−2.64	−3.47	−3.39	−3.71	−3.91	−3.96	−4.14	−3.09	−2.
0163	+1.12	+0.86	+0.37	−0.33	−0.44	−0.29	+0.26	−0.20	+1.07	+1.
0311	+1.59	+1.44	+0.74	+1.11	+1.34	+1.09	+0.56	−0.04	+1.07	+1.

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ashington, D. C., January 5 to June 12, 1905.

han 25 omitted.

Chronometer room. (Orientation changed for polarity test, one week on E., W., S., and N.)

74.60	74.81	72.32	74.60	73.96	71.86	71.92	68.35	70.68	71.26
33	31	34	42	48	52	48	57	59	61
Apr. 3 to Apr. 10.	Apr. 10 to Apr. 17.	Apr. 17 to Apr. 24.	Apr. 24 to May 1.	May 1 to May 8.	May 8 to May 15.	May 15 to May 22.	May 22 to May 29.	May 29 to June 5.	June 5 to June 12.
−1.16	−1.11	−0.99	−1.10	−1.00	−0.94	−1.03	−0.86	−0.89	−1.00
−0.59	−0.59	−0.60	−0.71	−0.66	−0.81	−0.71	−0.70	−0.73	−0.66
−1.47	−1.36	−1.49	−1.39	−1.50	−1.39	−1.53	−1.57	−1.34	−1.47
−0.20	−0.27	−0.17	−0.24	−0.16	−0.14	−0.33	−0.17	−0.26	−0.37
+0.13	−0.09	−0.14	−0.27	−0.17	−0.07	−0.16	−0.13	−0.31	−0.01
−0.90	−1.14	−1.19	−1.26	−1.14	Issued to the Illinois.				
+0.79	+0.60	+0.60	+0.63	+0.66	+0.49	+0.37	+0.46	+0.14	+0.20
+0.84	+0.69	+0.77	+0.69	+0.76	+0.73	+0.64	+0.81	+0.73	+0.70
−0.23	−0.46	−0.32	Issued to the Brutus.						
+0.74	+0.39	+0.03	+0.03	+0.16	−0.04	Issued to the Terror.			
−0.77	−0.99	−1.00	Issued to the Maryland.						
−2.61	−2.56	−2.23	−2.54	−2.50	−2.51	Issued to the Atlanta.			
+1.03	+0.87	+0.84	+0.71	+0.77	+0.71	+0.53	+0.71	+0.51	+0.43
+1.21	+0.83	+1.03	+0.80	+0.96	+0.80	+0.63	+0.67	+0.56	+0.59
+0.74	+0.46	+0.26	+0.20	+0.11	−0.07	−0.27	−0.14	Issued to Scorpion.	
−0.67	−0.74	−0.81	−0.80	−0.83	−0.97	−1.01	−1.09	−1.00	−0.96
+2.04	+1.87	+1.77	+1.66	+1.69	+1.59	Issued to the Atlanta.			
−2.19	−2.07	−2.04	−2.17	−2.09	−2.01	−2.13	−2.03	−1.96	−1.93
+1.67	+1.76	+1.63	+1.39	+1.53	+1.26	+1.21	+1.27	+1.40	+1.29
−0.50	−0.53	−0.50	−0.69	−0.71	Issued to the Illinois.				
−0.51	−0.61	−0.47	−0.63	−0.43	−0.49	−0.56	−0.40	−0.29	−0.30
+0.53	+0.30	+0.24	+0.24	+0.20	+0.06	−0.14	−0.06	−0.14	−0.09
+2.47	+2.46	+2.49	+2.59	+2.49	+2.41	+2.21	+2.20	+2.09	+2.14
−0.77	−0.86	−1.04	−0.99	−1.01	−1.19	−1.38	Issued to the Iowa.		
−0.21	−0.09	−0.40	Issued to the Maryland.						
+2.03	+1.74	+2.29	+1.80	+1.73	+1.79	+1.79	+1.74	+1.56	+1.46
−0.23	−0.07	−0.17	−0.49	−0.36	−0.26	−0.49	−0.59	−0.23	−0.29
−2.54	−2.47	−2.47	−2.71	−2.74	−2.87	−3.01	−3.20	−2.97	−3.04
+0.27	−0.13	+0.01	−0.20	−0.11	−0.06	−0.31	−0.17	−0.19	−0.19
−0.41	−0.47	−0.36	−0.83	−0.77	−1.01	−1.17	−1.16	−1.27	−1.29
+1.44	+1.43	+1.11	+1.09	+1.17	+1.03	+1.06	+1.14	+1.30	+1.36
−0.56	−0.74	−0.73	−0.69	−0.61	−0.83	Issued to the Terror.			
−0.76	−0.97	−1.30	−1.37	−1.40	−1.77	−1.83	−2.13	−1.86	−1.90
−3.59	−3.76	−4.18	Issued to the Maryland.						
+0.60	+0.71	−0.21	−0.09	+0.19	+0.29	Issued to the Atlanta.			
+0.96	+0.96	+1.01	+1.14	+0.91	+1.03	+0.54	+1.06	+0.54	−0.01

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School, however, should receive early attention. The Navy Department and the District Commissioners have practically come to an agreement as to the price to be paid for this property, as shown in the report to which reference was made a year ago, but as two or three years will be required for the school to be established elsewhere it will be necessary, in order to carry out the will of Congress in the near future, to submit to that body an estimate for the purchase of the property at an early date.

As Congress has, in the appropriation bill providing for the expenses of the Naval Observatory for the fiscal year 1905–6, restored the item of $10,000 for the care and grading of the grounds, which accords with the appropriation which existed up to July 1, 1902, it is expected that hereafter the grading of the ground within the Observatory limits can be carried on coincidently with that of the adjoining thoroughfares by the District government.

APPROPRIATIONS.

I feel it my duty again to call the attention of the Department to the totally inadequate force which is allowed by Congress to carry on the work of the Observatory. My last annual report treats this subject in extenso, and I urgently appeal for at least a gradual increase in the personnel which will permit the proper execution of the important duties devolving upon the staff and prevent the oft-repeated but ill-founded charge of inadequate amount of work for so large an institution.

Very respectfully, your obedient servant,

C. M. CHESTER,
Rear-Admiral, U. S. Navy,
Superintendent of the Naval Observatory.

The CHIEF OF THE BUREAU OF EQUIPMENT,
Navy Department.

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SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1906.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

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SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1906.

Rear-Admiral Colby M. Chester, U. S. Navy, was Superintendent of the Naval Observatory until his retirement on February 28, 1906. Rear-Admiral Asa Walker, U. S. Navy, assumed the duties of Superintendent on March 1, 1906.

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

This department was in charge of Commander T. D. Griffin, U. S. Navy, until the end of May. During June Lieut. Commander E. E. Hayden, U. S. Navy, was in charge.

The number of shipments made during the year was 400, amounting in value to $96,713.12. The value of the instruments received was, by purchase, $34,758.01, and by return from navy-yards, $84,383.66. The value of the stock on hand is $97,129.32.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department was temporarily in charge of Mr. E. A. Boeger, assistant in department of nautical instruments, until December 26, 1905, when Lieut. Commander E. E. Hayden, U. S. Navy, returning from the eclipse expedition, resumed charge.

The regular annual chronometer trial began on January 10, with the largest number of chronometers and torpedo-boat watches ever entered in such trial at this Observatory, namely, 42 new marine chronometers, 57 new torpedo-boat watches, 74 old chronometers, and 7 old watches, and more chronometers and watches were added as they were returned, cleaned, and repaired from the makers. The trial ended on June 11.

The accompanying tabular statements, Tables I, II, and III, give all the data and results of the trial for those instruments that were successful in obtaining a trial number of 25 or better, that being the highest allowed for new chronometers and watches.

An important amendment to the current specifications, No. 25, of May 15, 1903, for new chronometers, was recommended during the

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trial, accepted by the makers, and adopted by the Bureau of Equipment, as follows:

In case a new chronometer obtains a trial number greater than 25 in any trial held according to these specifications, and in case such chronometer has shown an actual acceleration of rate from the first to the second of the two observed mean daily temperature-room rates at 85° F., 70°, and 55°, respectively, its trial number shall be recalculated with an allowance for such acceleration to be determined and applied as follows: From the two observed temperature-room rates at 85° F., 70°, and 55°, respectively, calculate the mean daily acceleration at each of those temperatures; take the mean of these three means as the mean daily acceleration, or coefficient of time, of the chronometer; then, beginning with the first observed rate in the trial, apply this coefficient to all of the succeeding observed rates of the chronometer in order to reduce them for such assumed acceleration; finally, with these corrected rates calculate a new trial number; if such new trial number be less than 25 it shall be stated as 25.00 A in the final report of the trial, in place of the trial number that was first obtained; all other data and results of the trial, however, shall be of record as actually observed and calculated, according to the specifications.

The regular work of the department in connection with the rating and issue of chronometers, the testing of new chronometers, watches, and clocks, and the sending out of the daily telegraphic time signals has been heavier than usual during the year, as shown by the following brief summary, which, of course, does not include any account of the voluminous records and correspondence in connection therewith:

Number of chronometers received	215
Number of chronometers sent out	236
Number of watches received	264
Number of watches sent out	196
Number of stop and comparing watches tested	83
Number of deck and boat clocks tested	417

There were in the naval service at the close of the fiscal year 651 chronometers and 78 torpedo-boat watches, of an aggregate value of about $200,000, every one of which is either actually in use in navigation or being cleaned, repaired, and accurately rated for such use. The history of each is recorded very carefully, its location and condition are always known, and its performance at sea and at the Observatory must be observed and compared constantly in order to maintain the standard required for accurate navigation. Those that fail must be replaced by other and better ones and a reserve kept on hand ready for emergencies. All of this work is imperatively demanded by the sea going vessels of the Navy, and is now, and always has been, one of the most important duties of this Observatory. Incidently to this chronometer service, which, of course, always requires the most exact time, the telegraphic time service developed; and with no additional expense or trouble to the Navy the entire country is supplied, by means of the voluntary cooperation of the telegraph and telephone companies, with exact standard time daily. The mean daily error of the noon signal for the year is $0^s.045$, the maximum error on any day being $0^s.29$.

The attention of the Department is called to the need of an additional officer in this department and one also in that of nautical instruments. The work in each of these departments has increased more than twofold since just before the Spanish war, while the working force has not been enlarged.

COMPASS OFFICE.

This office was in charge of Commander George H. Peters, U. S. Navy, to November 13, 1905, and since that date has been in charge of Lieut. Commander, John M. Ellicott, U. S. Navy.

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This office was transferred to the Observatory on January 19, 1906, where the work of instruction to officers has since been conducted as well as the other official work of the office.

The superintendent of compasses points out the desirability of the assignment of a competent officer as an assistant in the office to relieve him when detached and to assist in the work of the office; also the need of a clerk for the office.

The supply of compasses and materials connected therewith has been sufficient to meet the current demands, but only a small supply in excess is on hand to meet an emergency.

Various improvements have been made in the instruments connected with this branch of navigation and instructions given as to their use. Valuable results have been obtained from the reports of navigators in the process of correcting variation on charts.

Special efforts have been made to determine the most suitable locations for compasses on board ships and submarines.

In connection with this report, the need of a separate building for the mounting of the Scorsby model, so that students may be able to utilize the sun for several hours of the day for compass observation, is strongly recommended.

NAUTICAL ALMANAC OFFICE.

This office has continued under the direction of Professor of Mathematics W. S. Harshman, U. S. Navy.

There have been received during the year from the Government Printing Office 705 copies of the first edition of the American Ephemeris and Nautical Almanac for 1906, 118 copies of the second edition of the American Nautical Almanac for 1905, 101 copies of the first edition of the American Ephemeris and Nautical Almanac for 1905, 1,727 copies of the first edition of the Pacific Coaster's Nautical Almanac for 1906, 500 copies of the first edition of the American Nautical Almanac for 1908, 2,549 copies of the first edition of the American Nautical Almanac for 1906, and 350 copies of the second edition of the American Ephemeris and Nautical Almanac for 1906.

During the present fiscal year the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris and Nautical Almanac	874	940	1,814
American Nautical Almanac	2,714	326	3,040
Pacific Coaster's Nautical Almanac	1,353	48	1,401
Astronomical Papers	51	28	79

The proceeds of sales, amounting to $1,933.28, have been deposited with the Treasurer of the United States to the credit of public printing.

The current work of this office is up to date. The ephemeris of Phoebe, the ninth satellite of Saturn, is now given for the first time in the American Ephemeris.

THE DIVISION OF EQUATORIAL INSTRUMENTS.

This division has continued in charge of Professor of Mathematics A. N. Skinner, U. S. Navy.

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The following observations have been made in this division during the year:

Satellites of Saturn	210
Satellites of Uranus	12
Bright satellites of Jupiter	58
Sixth satellite of Jupiter	9
Satellite of Neptune	30
5 comets	50
66 asteroids	302
Occultations of stars by the Moon	26
Photographs for asteroids	12
Miscellaneous observations	45
Total	754

It is the aim of the division of equatorial instruments to make measurements of position of comets, asteroids, and the satellites of the planets, and to observe the occultations of stars by the moon, which are predicted in the American Ephemeris. Determinations of several orbits of comets and asteroids have been made.

DIVISION OF MERIDIAN INSTRUMENTS.

This division has continued in charge of Professor of Mathematics W. S. Eichelberger, U. S. Navy.

During the absence of Professor Eichelberger in Europe, Professor Skinner was in charge of this division for the first five months of the year.

The 9-inch transit circle.—The plan of work decided upon for this instrument in the fall of 1903 has been continued during the year just ended.

The number of observations from July 1, 1905, to June 30, 1906, is as follows:

Zodiacal stars	2,062
Standard stars	3,819
Screen stars for personal equation	235
Zenith stars for personal equation	80
Sun	131
Moon	102
Mercury	29
Venus	82
Jupiter	16
Saturn	15
Uranus	8
Neptune	15
Total	6,594

The decrease in the number of observations as compared with the preceding two years is due to the five months' absence of Professor Eichelberger and Mr. Yowell, and to the suspension of regular observing work during May to permit of a determination of the errors of the circle graduations.

Three determinations of the horizontal flexure indicate no change from the values obtained during preceding years. Several determinations of the vertical flexure have been obtained by the use of a vertical collimator, giving a flexure of about 1″.

During the month of May four observers were engaged in the determination of the division errors of the circle graduations. A separate

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determination was made by each observer. Of the 180° diameters the errors of all multiples of 5° and of half of the remaining 144 diameters were completed. The errors of the remaining 72 diameters were determined by two of the observers, and will be determined during the summer by two others. At the same time the errors of the half-degree diameters will also be determined. The error of each diameter is thus determined independently four times, and the maximum range in any one of the 107 sets of four so far completed is 0″.34, and the mean probable error of the finally adopted corrections is less than 0″.025.

The reductions of the observations made with this instrument are badly in arrears for lack of sufficient computing force.

The 6-inch transit circle.—The final adoption of the plans for the self-registering right ascension micrometer for this instrument was postponed until the return of the recent eclipse party so that the results of observation at the European observatories might be available. The micrometer is now being constructed by the Warner & Swasey Company, of Cleveland, Ohio.

Astronomische Gesellschaft Zone Catalogue −13° 50′ to −18° 10′.—The different positions of each star in this zone as given in the four catalogues mentioned in the last annual report have been gathered together through the first ten hours of right ascension for a discussion of proper motion. It is hoped to finish this work for the remaining fourteen hours during the coming year and to prepare the printer's copy for the final catalogue. This work is being carried on under the direction of Professor Skinner and much of it is being done by him personally.

Washington Zone Catalogue.—During the present year the individual transit threads have been reduced to mean thread for almost all the zones. A number of discordant threads have thus been located, many wrong means have been discovered, and 48 transit zones have been found to have been reduced with incorrect thread intervals. Of the unpublished zone observations the 400 mural circle observations made in 1851 are now being reduced. The reduction of these unpublished zone observations is being carried on under the direction of Professor Littell.

Printing.—Since the last report, Appendix I, Volume IV, Publications of the United States Naval Observatory, Second Series: Total Solar Eclipses of May 28, 1900, and May 17, 1901, has been published. The completed Volume IV, containing all the meridian circle work to September, 1903, not heretofore published, together with a re-reduction by Prof. John R. Eastman, retired, of the observations of the sun, moon, planets, and comets, 1866–1891, is now in press.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

This division has continued in charge of Professor of Mathematics F. B. Littell, U. S. Navy.

The instrument has been used as a vertical circle for determining the declinations of the stars of Newcomb's Suggested List of Fundamental Stars, which culminate here at zenith distances less than 75°. The observing list comprises 1,186 stars for upper culmination and 136 stars for lower culmination. Each complete observation furnishes a double zenith distance of the star observed. Readings are made on

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two circle divisions under each of the four microscopes, and to facilitate this operation an extra set of double threads has been placed in each microscope at a distance of 2.5 revolutions of the micrometer screw from the original set. By this arrangement the principal periodic errors of the micrometer screws are also eliminated.

The number of star observations made during the year was 899. Some preliminary work has also been done in examining the division errors of the circle. The one observer attached to the instrument was absent from the Observatory for several months on eclipse duty in Spain and elsewhere.

The reductions are in a satisfactory state of progress.

A new building is urgently needed for this instrument. The present one was intended only as a temporary one, and it is very poorly adapted to the uses of the instrument.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

This division has continued in charge of Assistant Astronomer G. A. Hill, who was absent from the Naval Observatory on eclipse duty from July 1 to October 10, 1905.

Observing with this instrument has been continued by the method outlined in former reports. The total number of observations now made with this instrument and awaiting publication is 4,507, of which 1,282 are of α Lyræ. The number of observations made during the past year, comprising slightly less than nine months of observing, is 392.

The observations are completely reduced to April 30, 1905, and the reduction of those made since that time is well in hand.

THE PHOTOHELIOGRAPH.

This instrument has continued in charge of Photographer G. H. Peters during the year. During his absence on the eclipse expedition from July 1 to October 10, 1905, Mr. G. F. Coulon was temporarily in charge.

Photographs of the sun have been obtained on one hundred and sixty-eight days, on one hundred and sixty-six of which solar spots and faculæ were observed on the plates, including many large and important groups of spots.

THE LIBRARY.

The library has continued in charge of the librarian, W. D. Horigan.

	Volumes.	Pamphlets	Total.
Contents of the library July 1, 1905	19,696	4,203	23,899
Accessions	749	73	822
Contents July 1, 1906	20,445	4,276	24,721

Of the accessions 285 were received as exchanges and 537 were purchased.

Among the books purchased were a set of the Compte Rendu de l'Association Francaise pour l'Avancement des Sciences, Session 1–32, 1873–1903, in 51 volumes, and a set of the Nouvelles Annales de

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Mathematiques (Terquem et Gerono), Vols. 1–62, Paris, 1842–1903. The number of volumes bound for the library was 400.

There were distributed 2,064 copies of the various publications of the Observatory.

The routine work of the library is up to date.

THE TOTAL SOLAR ECLIPSE OF AUGUST 30, 1905.

The work on astronomical observations was much reduced by the absence of all but one of the regular heads of divisions, with several of their assistants, for periods ranging from four to six months, on the total solar eclipse expedition of 1905. Rear-Admiral Chester, late Superintendent of this Observatory, had personal charge of this expedition, and is now engaged in making out a full report of the same. His preliminary report is published in the Astrophysical Journal.

PUBLICATIONS.

During the fiscal year ending June 30, 1906, Volume IV, Appendix I, has been issued. The completed Volume IV, containing about 800 pages, is now being bound at the Government Printing Office.

As showing the contributions to astronomy in general in other than Government publications, the following list of articles made public is submitted:

In the Astrophysical Journal of March, 1906: "Preliminary results of the United States Naval Observatory Eclipse Expedition in 1905," by Colby M. Chester.

In Popular Astronomy for August and September, 1905: "The requisites of a transit observer," by Geo. A. Hill. "A differential method generally applicable to all solutions proceeding by successive approximations, and especially available when these approximations practically fail to converge," by Herbert L. Rice.

In Popular Astronomy for October, 1905: "An untried method of determining the constant of refraction," by Geo. A. Hill.

In Popular Astronomy for May, 1906: "Given the elements of an asteroid to compute, differentially, its daily motion in geocentric right ascension," by Herbert L. Rice.

In the Astronomische Nachrichten, Nr. 4029: "Elements of (532) Herculina and ephemeris for opposition of 1905," by J. C. Hammond.

In the Astronomische Nachrichten, Nr. 4050: "Provisional elements of 1905 QU," by J. C. Hammond.

In the Astronomical Journal, No. 580: "Elements and ephemeris of comet *b* 1905 (Schaer)," by Eleanor A. Lamson.

In the Astronomical Journal, No. 583: "Elements and ephemeris of comet *a* 1906 (Brooks)," by Eleanor A. Lamson.

In the Astronomical Journal, Nos. 584–585: "The proper motion of B.D.+38° 3095," by Geo. A. Hill.

Also numerous observations of satellites, asteroids, comets, and occultations of stars by the moon.

BUILDINGS, GROUNDS, AND ROADS.

The buildings are generally in good condition, and the roads are well kept.

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Grading has been continued on the northeastern portion of the grounds and on the hill at the southwest on plat purchased from Mr. Theo. Barnes. The plat formerly owned by Mr. Philip Young has been acquired and title completed. Fifty-three hundred and forty-two feet of wire fence have been erected under contract, No. 7164, of June 22, 1905, with the New Jersey Foundry and Machine Company.

After consultation with the District Commissioners, a bill was framed and introduced in the Senate, S. 5873, for the acquisition of the property known as the Industrial Home School property. The acquisition of this property is deemed very desirable in order that objectionable features now prevalent in that locality may be removed, and, incidentally, needed accommodations for observers may be obtained.

The plat of 1.732 acres, a part of the property known as "Normanstone," still remains to be acquired, and proceedings for its condemnation are before the court. It seems desirable that these proceedings be expedited and title to the property obtained.

The Superintendent renews the recommendation of a former Superintendent that none of the property belonging to the Observatory tract outside the circle be sold.

ESTIMATES.

In the department of astronomical observations there are large arrears of work on observations made, some of them as many as fifty years ago. The reduction of these observations should be completed and the work of the Observatory brought up to date. With the present force of computers it is practically impossible to do this. An increase in the number of assistants in this department or an increase in the appropriation for miscellaneous computations is urgently needed.

It is further recommended by the Superintendent that the titles of the employees now called "computers, assistant on the equatorial, and assistant in spectroscopic work," be changed to "assistants in making and reducing astronomical observations," and that one assistant at $1,600 and two at $1,400, in place of two computers at $1,200, be allowed

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rification No. 25 of May 15, 1903, 1906.

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onometer room. (Orientation changed for polarit

	74.76	73.72	73.74	74.00	65.15
	49	46	53	53	62
	Apr. 9 to Apr. 16.	Apr. 16 to Apr. 23.	Apr. 23 to Apr. 30.	Apr. 30 to May 7.	May 7 to May 1
	s.	*s.*	*s.*	*s.*	*s.*
9	+0.51	+0.40	+0.24	+0.19	−0.1
4	+0.19	+0.06	+0.24	+0.16	+0.1
6	−1.53	−1.54	−1.47	−1.56	−1.5
1	+0.20	+0.01	+0.01	+0.10	−0.2
4	−0.61	−0.77	−0.86	−0.53	−1.1
9	+0.77	+0.70	+0.77	+0.51	+0.5
6	+0.96	+0.68	.....	.....	.....
0	+1.80	+1.61	+1.49	+1.56	+1.2
7	−0.01	−0.11	−0.17	−0.44	−0.3
6	+0.13	+0.20	−0.20	−0.21	−0.0
6	−0.29	−0.43	−0.61	−0.64	−0.6
1	−1.43	−1.87	−2.04	−1.47	−1.7
3	+1.00	+1.06	+0.87	+0.83	+0.6
3	+0.63	+0.51	+0.36	+0.33	+0.0
3	−0.40	−0.59	−0.79	−0.77	−0.7
0	+0.99	+0.73	+0.56	+0.41	+0.1
3	+0.24	+0.23	+0.13	+0.14	+0.2
6	−0.51	−0.51	−0.64	−0.67	−0.5
1	−0.51	−0.99	−1.29	−1.33	−1.6
1	−0.90	−1.21	.....	.....	−1.4
1	−1.31	−2.10	−2.24	−2.23	−2.0
7	−1.44	−1.56	−1.76	−1.83	−1.5
3	−1.49	−1.64	.....	−1.39	−2.1
3	+2.43	+0.13	−0.27	−0.13	−0.6
0	+1.37	+1.16	+0.93	+0.93	+0.6
6	−1.66	−1.95	.....	.....	.....
7	+0.24	+0.14	−0.14	−0.20	−0.4

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room. (Orientation changed for polarity test, one week on E., W., S., and N.)

6	78.72	73.74	74.00	65.15	69.04	71.11	70.50	74.98
	46	53	53	62	64	66	60	72
9 6.	Apr. 16 to Apr. 23.	Apr. 23 to Apr. 30.	Apr. 30 to May 7.	May 7 to May 14.	May 14 to May 21.	May 21 to May 28.	May 28 to June 4.	June 4 to June 11.
	s.	s.	s.	s.	s.	s.	s.	s.
84	−1.67	−1.86	−1.83	−1.90	−1.90	−1.87	−1.57	−1.66
37	−0.43	−0.54	−0.49	−0.53	−0.54	−0.50	−0.54	−0.24
23	+1.33	+1.04	+1.37	+1.24	+1.19	+1.14	+0.74	+0.80
47	+1.41	+1.33	+1.37	+1.96	+1.69	+1.80	+1.87	+1.80
81	−0.66	−0.73	−0.80	−0.70	−0.81	−0.77	−0.57	−0.63
76	−2.60	−2.94	−3.07	−2.90	−2.93	−3.09	−3.14	−3.43
26	−3.07	−3.06	−2.90	−2.69	−2.94	−2.94	−3.00	−3.27
11	+1.76	+1.66	+1.89	+1.69	+1.80	+2.47	+1.94	+1.86
84	−4.60	−4.73	−4.90	−4.81	−5.14	−5.14	−5.27	−5.29
76	−4.54	−4.73	−4.87	−4.79	−5.00	−5.19	−5.14	−5.20
01	−2.89	−2.90	−3.19	−2.80	−2.93	−3.06	−2.47	−2.14
43	+0.11	+0.29	+0.49	+0.57	+0.60	+1.07	+0.69	+0.79
14	−5.59	−5.36	−5.46	−5.33	−5.27	−4.94	−5.03	−4.91
47	+1.54	+1.61	+2.06	+1.43	+1.71	+2.03	+1.63	+1.77
23	−1.39	−1.19	−1.37	−1.49	−1.14	−0.93	−0.93	−0.97
00	+3.83	+3.77	+3.74	+4.34	+3.90	+3.79	+3.64	+3.43
03	+3.23	+3.63	+3.76	+3.19	+3.77	+3.61	+3.36	+3.39

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	74.76	73.72	73.74	74.00	65.15	
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	s.	s.	s.	s.	s.	
3	−0.41	−0.33	.....	.....	−0.56	
1	+3.00	+3.03	+2.94			Is
1	−0.20	−0.29	−0.53			Is
7	−0.99	−0.84	−1.37			Is
3	+1.87	+1.84	+1.80	+1.97	+2.01	
3	+0.66	+0.66	+0.50	+0.59	+0.77	
7	−0.79	−0.96	−1.19	−1.20	−1.06	
3	+0.54	+0.57	+0.50	+0.50	+0.61	
6	+1.10	+1.00	+0.63			I
7	−0.96	−1.11	−1.11	−1.23	−1.31	
3	+0.27	+0.19	+0.16	+0.06	+0.17	
6	−0.97	−1.04	−1.34			I
6	−0.49	−0.59	−0.63	−0.54	−0.77	
0	+0.04	+0.23	−0.12			I
3	+0 31	+0.39	−0.31	−0.49	+0.11	
1	−0.10	−0.16	−0.30	−0.34	−0.06	
1	+0.43	+0.09	+0.17	+0.20	+0.13	
3	+1.99	+1.93	+1.90	+1.91	+2.00	
1	−1.09	−1.23	−1.53	−1.51	−1.14	
6	−0.20	−0.24	−0.26	−0.34	+0.21	
7	−1.73	−2.03	−2.20	−1.96	−1.49	
8	+3.23	+3.13	+3.30	+3.24	+4.00	
7	−0.44	−0.61	−0.64	−0.76	−0.80	
7	−3.16	−3.33	−3.36	−3.46	−4.04	
6	−0.46	−0.67	−0.76	−0.69	−1.54	
4	−0.27	−0.27	−0.47	−0.39	−0.36	
4	+0.66	+0.50	+0.27	+0.44	−0.40	
1	−0.11	−0.14	−0.46	−0.39	−0.8'	
0	−4.01	−4.17	−4.17	−4.26	−4.1	
9	−0.84	−0.99	−1.00	−1.09	−1.1	
6	+0.27	+0.07	−0.33	−0.51	−0.2	
0	−0.74	−0.91	−1.00		Issu	
0	+2.36	+2.49	+2.53	+2.47	+3.1	
8	+2.07	+2.11	+1.79			
4	+1.97	+1.97	+1.87	+1.86	+2.1	
6	−1.66	−1.51	−1.87	−2.16	−1.7	
4	−1.86	−2.06	−2.24	−2.30	−2.1	
4	+0.20	−0.01	−0.11	−0.19	−0.1	
3	−1.39	−1.61	−1.73	−1.70	−2.1	
9	−0.96	−0.94	−0.87	−0.90	−0.1	

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NAVY DEPARTMENT

UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1907

WASHINGTON

GOVERNMENT PRINTING OFFICE

1908

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SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1907.

Rear-Admiral Asa Walker, U. S. Navy, was Superintendent of the Naval Observatory throughout the year.

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

This department was in charge of Commander T. D. Griffin, U. S. Navy.

The number of shipments made during the year was 558, amounting in value to $115,954.22. The value of the instruments received was, by purchase, $47,417.39, and by return from navy-yards, etc., $77,883.91. The value of the stock on hand is $100,000.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department was in charge of Commander E. E. Hayden, U. S. Navy.

The regular annual chronometer trial began December 31, 1906, and ended June 3, 1907. The total number of instruments under trial, only slightly less than last year, was as follows: Thirty-three new chronometers, 35 new torpedo-boat watches, and 100 old naval chronometers.

The accompanying tabular statements, Tables I, II, and III, give all the data and results of the trial for those instruments that were received in time and that obtained a trial number of 25 or less.

The regular work of the department in connection with the rating and issue of chronometers, the testing of new chronometers, watches, and clocks, and the sending out of the daily telegraphic time signals has been heavier than usual during the year, as shown by the following brief summary, which of course does not include any account of the voluminous records and correspondence therewith:

Number of chronometers received	262
Number of chronometers sent out	255
Number of watches received	272
Number of watches sent out	248
Number of clocks received	194
Number of clocks sent out	194

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The mean daily error of the noon signal for the year was $0^s.073$, the maximum error on any day being $0^s.56$.

The attention of the Department is invited to the need of an additional officer in this department and one also in that of nautical instruments.

COMPASS OFFICE.

This office was in charge of Lieut. Commander J. M. Ellicott, U. S. Navy, from July 1, 1906, to August 10, 1906, and in charge of Commander Thomas Snowden, U. S. Navy, from August 10, 1906, to June 30, 1907.

The superintendent of compasses points out the desirability of the assignment of a competent officer as an assistant and also the need of a clerk in the office.

The supply of compass material in stock is barely sufficient to meet current demands, and it is recommended that a slightly greater margin of supplies be kept on hand in order to be prepared for emergencies.

The recommendation of last year that a special building be provided for the mounting of the experimental machine Scoresby, so that students may utilize the sun in compass work, is renewed.

This office tests all compasses before delivery, takes magnetic observations on all new ships to determine the fitness of their compass stations, and to obtain information to be used in locating compasses in future ships and for data for instruction of officers taking the course of instruction offered by the office. During the year 14 officers have taken this course.

NAUTICAL ALMANAC OFFICE.

This office has continued under the direction of Professor of Mathematics W. S. Harshman, U. S. Navy.

There have been received during the year from the Government Printing Office 700 copies of the American Ephemeris and Nautical Almanac for 1907, second edition; 2,900 copies of the American Nautical Almanac for 1907, second edition; 200 copies of the American Ephemeris and Nautical Almanac for 1907, third edition; 1,000 copies of the American Ephemeris and Nautical Almanac for 1909, first edition; 500 copies of the American Nautical Almanac for 1909, first edition; 1,000 copies of the American Ephemeris and Nautical Almanac for 1910, first edition; and 500 copies of the American Nautical Almanac for 1910, first edition.

During the present fiscal year the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris and Nautical Almanac	79	1,081	1,160
American Nautical Almanac	784	242	1,026
Pacific Coaster's Nautical Almanac	74	1	75
Astronomical papers	5	90	95

The proceeds of sales, amounting to $328.58, have been deposited with the Treasurer of the United States to the credit of public printing.

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The distribution of miscellaneous publications, Astronomical Constants, Zodiacal Catalogue, Star Tables, Tables of the Moon, etc., has continued through the year.

By direction of the Secretary of the Navy the sale of publications of the Nautical Almanac Office was transferred to the superintendent of documents, Government Printing Office, October 1, 1906. Since that date the superintendent of documents has been supplied by the Navy Department with the following publications for sale:

	Copies.
American Ephemeris and Nautical Almanac	1,150
American Nautical Almanac	3,094
Atlantic Coaster's Nautical Almanac	90
Pacific Coaster's Nautical Almanac	227
Astronomical Papers	870

The current work of the office is up to date. The ephemeris of the sixth satellite of Jupiter is now given for the first time in the American Ephemeris, and the reductions are being made preparatory to publishing the ephemeris of the seventh satellite of Jupiter.

THE DIVISION OF EQUATORIAL INSTRUMENTS.

This division has continued in charge of Professor of Mathematics A. N. Skinner, U. S. Navy.

The following observations have been made during the year:

Satellites of Mars	8
Satellites of Saturn	111
Satellites of Uranus	30
8 comets	57
58 asteroids	238
Double stars	10
Comparison stars	4
Miscellaneous stars	54
Occultations of stars by Moon	9
Total observations	521

It is the aim of the division of equatorial instruments to make measurements of the positions of comets, asteroids, and the satellites of the planets, and to observe as far as is practicable the occultations of stars by the moon which are predicted in the American Ephemeris. Determinations of the orbits of several comets and asteroids have been made during the year.

The number of visitors received by permit for a view of the heavens through the 12-inch equatorial has been 1,065.

THE DIVISION OF MERIDIAN INSTRUMENTS.

This division has continued in charge of Professor of Mathematics W. S. Eichelberger, U. S. Navy.

The 9-inch transit circle.—The plan of work decided upon for this instrument in the fall of 1903 has been continued during the year just ended. The work of obtaining four observations of each star in Sir David Gill's Zodiacal Catalogue of 2,798 stars was completed in October, 1906, with the exception of a few stars which need one more observation each. These stars are so scattered in right ascension that it will take until the autumn of 1907 to obtain the desired observations.

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The number of observations from July 1, 1906, to June 30, 1907, is as follows:

Zodiacal stars	1,175
Standard stars	1,709
Miscellaneous stars	22
Screen stars for personal equation	150
Zenith stars for personal equation	232
Sun	63
Moon	46
Mercury	27
Venus	52
Mars	6
Saturn	11
Uranus	6
Total	3,499

The determination of the division errors of the circle graduations has been continued. The corrections for all the degree and half-degree divisions and one-third of the remaining ones have been determined.

In order to better protect the instrument from the sun's rays during the observation of the sun, a new sunshade 4 feet wide and 43 feet long containing an 8-inch circular hole has been mounted to run on curved tracks, one on each side of and parallel to the meridian of the instrument. When not in use this shade is wound around a drum situated between the south collimator pier and the south wall. By means of this shade both collimators and their piers, together with the transit circle and its piers, are protected from the direct rays of the sun at apparent noon. Only the object-glass of the transit circle receives the sunlight.

The erection of this shade and a determination of the pivot errors of the transit circle prevented for several months the use of the instrument for observing.

The apparent right ascension and declination of the observations to April, 1907, have been obtained, with the exception of the application of the clock corrections, flexure corrections, corrections for division error and those for variation of latitude. The reductions to mean place are computed to March, 1905.

The 6-inch transit circle.—In October, 1906, the new self-registering transit micrometer, made for this instrument by the Warner & Swasey Company, was brought into use, and since then something over 3,000 star transits have been observed by five different observers. A discussion of these observations confirms the results obtained by other observers, that the relative personal equation of different observers is of the same order as its probable error. The relative personal equation of two of the five observers as determined by the key method of observing is $0^s.20$.

Clock vault.—During August, 1906, the roof of the old magnetic vault caved in, and in making repairs it was decided to utilize this old vault, which has not been in use for nearly ten years, for a clock vault. The old piers for the magnetic instruments have been removed, clock piers have been built, a new concrete roof 10 inches thick and covered with 2 feet of earth has been constructed, and a hot-water heating plant installed.

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Astronomische Gesellschaft Zone Catalogue −13° 50′ to −18° 10′.—The work on this catalogue is finished and the printer's copy completed except for a discussion of the proper motions in which Professor Skinner is now engaged. In this work catalogues in addition to the four mentioned in previous reports will be used whenever possible.

Washington Zone Catalogue.—The zone corrections have been applied to all the published results obtained with the mural circle and the transit instrument, and the comparison with the Cordoba General Catalogue for a determination of the zone corrections is about one-third completed for the meridian circle zones.

Printing.—During the past year Volume IV, Publications of the United States Naval Observatory, Second Series, mentioned in the last annual report as in press, has been distributed.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

This division has continued in charge of Professor of Mathematics F. B. Littell, U. S. Navy.

The instrument has been used as a vertical circle for determining the declinations of the stars of Newcomb's Suggested List of Fundamental Stars which culminate here at zenith distances less than 75°. The observing list comprises 1,186 stars for upper culmination and 136 stars for lower culmination. The number of observations obtained during the year was 1,489.

The reductions are in a satisfactory state of progress.

The divisions of the circle having become badly worn by repeated cleanings, it is proposed to have the circle regraduated in the near future, and it is hoped that a way will be found of avoiding the troubles hitherto experienced from the tarnishing of the silver graduated strip and from rust gathering at the junction of the silver strip with the steel circle.

Plans and specifications for a new house, with movable roof, have been made and an appropriation secured for it from Congress, and it will be erected during the present fiscal year.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

This division has continued in charge of Assistant Astronomer G. A. Hill.

The same method has been used in observing with the instrument as has been outlined in former reports. The transit is in good working order, as well as the apparatus connected therewith. There were made with it during the past year 429 observations.

The observations secured with the instrument are reduced, checked, and copied on the printer's form up to January 1, 1907. The observations awaiting publication now amount to 4,953, would make a volume of 620 pages, and, including about 100 additional pages for the introduction, one of the size usually issued by the Observatory.

The observer is now engaged in discussing the observations secured by the polygon method in the years 1904, 1905, and 1906, for the purpose of obtaining a value of the Constant of Aberration therefrom.

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THE PHOTOHELIOGRAPH.

This instrument has continued in charge of Assistant G. H. Peters.

The sun has been photographed with the photoheliograph on one hundred and fifty days, and solar spots were observed on these plates on one hundred and forty-eight days. This is a slight decrease from the number obtained during the previous fiscal year and is due to the great amount of cloudiness prevailing during the period covered by this report.

Two enormous groups of solar spots were observed during this period, one in February and the other in June. The former group was one of the largest ever noted, and both were announced from here and received much attention from the press.

The total number of solar negatives now on hand is 1,455, and it seems desirable to measure and reduce them. The process of measuring the coordinates of the spots on a dividing engine and their subsequent reduction involves an immense amount of labor. It is suggested that a heliomicrometer as devised by Professor Hale be installed. The plates can then be accurately measured and an enormous amount of computing avoided, thus economizing time and hastening results. The record of the spots at present gives only approximate positions, which are not available for scientific discussion, being tabulated merely for reference.

THE LIBRARY.

The library has continued in charge of the librarian, W. D. Horigan.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1906	20,445	4,276	24,721
Accessions	467	93	560
Contents July 1, 1907	20,912	4,369	25,281

Of the accessions, 331 were received as exchanges and 229 were purchased.

There were distributed 2,569 copies of the various publications of the Observatory.

The routine work of the library is up to date.

PUBLICATIONS.

During the fiscal year ending June 30, 1907, Volume IV has been issued.

As showing the contributions to astronomy in general in other than Government publications, the following list of articles made public is submitted:

In the Proceedings of the Seventh Session of the International Railway Congress Association: "A telegraphic time signal in honor of the International Railway Congress," by E. E. Hayden.

In Science of March 22, 1907: "Clocks—Ancient and modern," address of the retiring vice-president of Section A, American Association for the Advancement of Science, by W. S. Eichelberger.

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In Science of June 28, 1907: "The clock of the U. S. Naval Observatory," by W. S. Eichelberger.

In the Astronomical Journal, No. 587: "A comparison of two methods of obtaining level corrections in prime vertical transit observations," by Geo. A. Hill.

In the Astronomische Nachrichten, Nr. 4102: "Provisional elements and ephemeris of 1906 U J," by J. C. Hammond and Matt Frederickson.

In the Astronomische Nachrichten, Nr. 4129: "Provisional elements of (600) [1906 U M]," by J. C. Hammond and Matt Frederickson.

In the Astronomische Nachrichten, Nr. 4139: "Elements and ephemeris of comet 1906 *h*," by Eleanor A. Lamson.

In the Astronomische Nachrichten, Nr. 4156: "Provisional elements of planet 1906 V L," by J. C. Hammond. "Finding ephemeris for (581) Tauntonia," by Herbert R. Morgan.

In the Astronomische Nachrichten, Nr. 4157: "Elements of the minor planet 1906 W O = (260) Huberta," by Matt Frederickson.

In the Astronomische Nachrichten, Nr. 4172: Elements and ephemeris of comet 1907 *b*," by Eleanor A. Lamson and C. W. Frederick.

In the Astronomische Nachrichten, Nr. 4173: "Elements of comet 1907 *a*," by Eleanor A. Lamson.

In the Astronomische Nachrichten, Nr. 4183: "Provisional elements of 1906 W P," by J. C. Hammond. "Elements of (245) Vera," by Eleanor A. Lamson.

In Popular Astronomy for October, 1906: "The effect of temperature upon the constants of a transit circle," by Herbert R. Morgan.

Also numerous observations of satellites, asteroids, and comets.

A lecture on "The sun and solar eclipses" was given before the Pi Beta Phi Sorority of the George Washington University on March 6, 1907, by Geo. H. Peters.

BUILDINGS, GROUNDS, AND ROADS.

The buildings are in good condition. All of those containing instruments were painted last fall and minor repairs made.

Accommodations for the observers have been improved, adding much to their comfort.

A 125-horsepower boiler has been installed for heating, and all the clock circuits have been rewired with lead-incased wires.

The roads have been kept in repair. About 100 yards of concrete pavement has been laid. A large fill was made in the northeast portion of the circle and the grade brought up to that of Massachusetts avenue; but when repairs were made on the avenue its grade was raised, in places 4 feet, thus necessitating a still further fill in the Observatory grounds.

Nothing has been done with reference to the acquisition of the grounds of the Industrial Home School and the Normanstone tract, which lie within the defined boundary of the Observatory. This latter tract has been before the court for condemnation for three years, but the case has not been pushed. It is recommended that title be acquired to both of these tracts.

It is recommended that none of the land belonging to the Observatory tract outside of the circle be sold.

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ESTIMATES.

It has been found impossible to obtain a sufficient force of computers from the civil service, so that, with a great amount of work waiting to be done, a part of the appropriation for miscellaneous computing has been covered into the Treasury. The rates of pay for the present assistants at the Observatory were established in 1891. Since that date there has been change in but one salary, a raise of $200. It is earnestly recommended that the pay be increased. It is probable that with the incentive of promotion with better pay we might be able to retain the services of the employees in these positions. At present hardly does an assistant get thoroughly familiar with his duties before he resigns to take some office paying a higher salary.

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tion No. 16 C 1, of August 25, 1906), United States Naval

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r room. (Orientation changed for polarity test, one week on E., W., S., and N.)

7	70.43	69.49	71.56	69.48	68.92	69.82	67.38	68.71
	44	51	54	64	58	64	66	65
1 8.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13.	May 13 to May 20.	May 20 to May 27.	May 27 to June 3.
	s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
27	+0.24	+0.20	+0.17	+0.23	+0.30	+0.36	+0.31	+0.24
16	+1.23	+1.04	+1.37	+0.94	+0.97	+1.07	+1.13	+1.19
54	−0.87	−1.04	−0.94	−0.80	−0.93	−0.79	−0.73	−0.84
86	−0.93	−1.07	−0.84	−0.81	−0.61	−0.53	−0.37	−0.41
57	−0.64	−0.60	−0.81	−0.70	−0.69	−0.71	−0.71	−0.79
73	−1.94	−1.80	−1.91	−1.97	−2.17	−2.27	−2.46	−2.50
57	−0.73	−0.76	−0.91	−0.61	−0.66	−0.74	−0.83	−0.80
96	−2.16	−2.17	−2.33	−2.40	−2.59	−2.64	−2.57	−2.64
50	−0.29	+0.66	−0.20	+0.49	+0.16	+0.11	+0.23	+0.37
77	−0.96	−0.77	−0.81	−0.93	−1.14	−1.13	−1.31	−1.33
26	−1.43	−1.17	−1.29	−1.27	−1.46	−1.57	−1.50	−1.29
63	−0.54	−0.61	−0.74	−0.70	−0.84	−0.81	−0.66	−0.39
31	−2.47	−2.36	−2.53	−2.76	−2.69	−2.74	−2.56	−2.49
83	+0.44	+0.51	+0.33	+0.30	+0.39	+0.29	+0.53	+0.26
31	−1.53	−1.00	−0.89	−1.09	−0.87	−0.69	−0.47	−0.80
03	−0.23	−0.17	−0.17	−0.16	−0.24	−0.27	−0.19	−0.09
81	−2.89	−3.14	−3.30	−3.76	−3.70	−3.53	−3.40	−3.63
11	−0.27	−0.23	−0.43	−0.11	−0.24	−0.39	−0.41	−0.34
73	−1.09	−0.90	−1.03	−1.07	−1.36	−1.40	−1.13	−1.07
64	+0.37	+0.37	+0.16	+0.14	+0.03	−0.19	0.00	+0.19
23	−1.56	−1.57	−1.84	−1.76	−1.87	−1.93	−1.54	−1.61
70	+0.36	+0.47	+0.14	+0.19	+0.01	−0.33	−0.01	+0.21

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TA *States Naval Observatory, Washington, D. C., January 0 to*

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r room. (Orientation changed for polarity test, one week on E., W., S., and N.)

Order of merit.	Te 27	70.43	69.49	71.56	69.48	68.92	69.82	67.38	68.71
	Re	44	51	54	64	58	64	66	65
	. 1 8.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13.	May 13 to May 20.	May 20 to May 27.	May 27 to June 3.
		s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
1	.46	−3.41	−3.19	−3.27	−3.20	−3.23	−3.06	−3.03	−3.07
2	.96	−2.06	−1.89	−2.03	−1.79	−1.90	−2.07	−2.07	−2.01
3	.74	−1.67	−1.44	−1.31	−1.50	−1.36	−1.23	−1.26	−1.17
4	.79	−0.67	−1.30	−1.11	−0.71	−0.90	−1.04	−1.03	−1.30
5	.43	−0.36	−0.27	−0.29	−0.11	−0.10	−0.17	+0.03	+0.16
6	.57	−0.59	−0.17	−0.21	−0.19	−0.36	−0.11	−0.23	+0.07
7	.44	−2.70	−2.90	−2.87	−2.80	−2.66	−2.57	−2.39	−2.46
8	.09	+3.20	+3.11	+3.16	+3.41	+3.44	+3.50	+3.47	+3.33
9	.30	+0.17	+0.16	+0.44	+0.44	+0.39	+0.23	+0.26	+0.41
10	.03	−1.09	−0.59	−1.03	−0.87	−0.99	−1.20	−1.10	−1.24
11	.34	+0.36	+0.34	+0.27	+0.26	+0.60	+0.14	−0.13	−0.27

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r room. (Orientation changed for polarity test, one week on E., W., S., and N.)

Order of merit.		1	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13	May 13 to May 20.	May 20 to May 27.	Last week omitted.
	Temp	7	70.43	69.49	71.56	69.48	68.92	69.82	67.38	
	Relati		44	51	54	64	58	64	66	
			s.	s.	s.	s.	s.	s.	s.	
1	Bl									
2	Ne	06	+1.91	+2.09	+1.87	+2.09	+1.94	+1.91	+2.20	.....
3	Bl	29	−0.36	−0.33	−0.47	−0.60	−0.50	−0.51	−0.41	.....
4	.....	54	+0.74	Issued to the Kearsarge.						
5	.....	27	+1.23	+1.29	+1.13	Issued to the Missouri.				
6	Ne	13	+0.40	Issued to the St. Louis.						
7	.....	51	+1.69	+1.84	+1.70	+1.91	+1.86	+1.81	To Olympia.	
8	Ne	11	+0.03	+0.01	−0.09	Issued to the Sterling.				
9	Bl	34	+2.69	+2.70	+2.83	+2.74	+2.93	Issued for observatory use.		
10	.....	10	+1.19	+1.26	+1.24	Issued to the Abarenda.				
11	.....	50	−0.39	−0.46	−0.97	Issued to the Iowa.				
12	Ge	04	+0.83	Issued to the Alabama.						
13	Ne	57	−0.93	−0.51	−0.89	−0.66	−0.91	−0.80	−0.94	.....
14	Be	19	−0.21	−0.19	−0.27	−0.30	−0.30	−0.33	−0.24	.....
15	Ne	17	+1.14	+1.11	+1.11	Issued to the Ohio.				
16	Bl		Issued to branch hydrographic office, Galveston.							
17	Be	40	−0.61	−0.34	−0.46	Issued to the Worden.				
18	Se	00	+0.21	+0.10	−0.13	Issued to the Marcellus.				
19	Ne		Issued to the Cleveland.							
20	Bl									
21	Ne		Issued to the Brooklyn.							
22	Jo		Issued to the Denver.							
23	Ge	31	−1.46	−1.31	−1.34	−1.40	−1.49	−1.60	−1.59	.....
24	Bl		Issued to the Lebanon.							
25	Ne	21	0.00	Issued to the Alabama.						
26			Issued to the Denver.							
27	.....	40	+0.23	Issued to the St. Louis.						
28	.....	56	−1.13	−1.14	−1.24	−1.10	−1.21	−1.26	−1.23	.....
29	Be	06	+0.50	+0.77	+0.90	+0.67	+0.56	+0.69	+0.67	.....
30	Ne	07	−0.70	−0.73	−0.77	−0.63	−0.80	−0.71	−0.64	.....
31	.....	53	+1.44	+1.37	+1.39	+1.36	+1.24	+1.29	+1.10	.....
32	.....	59	+0.60	+0.43	+0.37	+0.49	+0.33	+0.37	+0.31	.....
33	.....		Issued to the Stewart.							
34	Bl	06	+1.03	+0.99	+1.04	+1.03	+1.06	+1.06	+1.09	.....
35	Ne	33	+1.44	+1.63	+1.53	Issued to the Sterling.				
36	Bl	29	−1.94	−1.90	−1.81	Issued to the Hopkins.				
37	.....	03	−1.96	−1.96	−1.87	−1.87	−1.87	−1.87	−1.96	.....
38	Ne		Issued to the Cleveland.							
39	.....		Issued to the Minnesota.							
40	.....	29	+0.61	+0.60	+0.59	+0.40	+0.31	+0.53	+0.37	.....
41	Bl	50	−0.67	−0.50	−0.60	−0.31	−0.21	−0.11	+0.06	.....
42	Bo	30	+0.17	+0.23	+0.01	+0.41	+0.47	+0.34	+0.54	.....
43	Ne	27	−2.66	−2.07	−2.51	Issued to the Hannibal.				
44	.....		Issued to branch hydrographic office, Philadelphia.							
45	.....	11	−0.97	−0.63	−0.89	−0.79	−1.00	−1.00	−0.73	.....
46	.....	11	−1.26	−1.33	−1.16	−1.27	−1.37	−1.37	To the Brutus.	
47	Bl	37	+0.17	+0.10	−0.14	−0.30	−0.30	−0.41	−0.39	.....
48	.....	10	+0.37	+0.53	+0.40	+0.59	+0.27	+0.19	+0.19	.....
49	De	31	+1.99	+1.83	+1.66	Issued to the Glacier.				
50	Ne	27	−0.73	−0.77	−1.06	−1.17	−1.39	−1.37	−1.46	.....
51	Bl		Issued to Fort Monroe, Time Signal Station.							
		16	−0.61	−0.61	−0.67	−0.71	−0.84	−0.80	To the Alliance.	
			Issued to the Rhode Island.							

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NAVY DEPARTMENT

UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1908

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1908.

Rear-Admiral Asa Walker, U. S. Navy, was Superintendent until his retirement, November 13, 1907. Capt. W. J. Barnette, U. S. Navy, assumed the duties of Superintendent on December 2, 1907.

Feeling the need of more detailed information regarding the work of the Department of Astronomical Observations, the following order was issued organizing a board to report on the various subjects therein mentioned:

U. S. NAVAL OBSERVATORY,
Washington, D. C., May 9, 1908.

GENTLEMEN: The recent written suggestions of the staff of the observatory regarding the future plan and scope of work indicate an unanimity of opinion that the chief efforts of the observatory should be in the direction of fundamental meridian work of the highest possible order, first to furnish the data necessary for the computations of the American Ephemeris, and secondly, to meet the requirements of astronomers in this particular branch of their work. Several eminent astronomers concur in this opinion.

Giving due weight to the above opinions and having in view the best interests of the observatory, I desire that the officers named below, acting as a board, shall consider the above written suggestions of the staff of the observatory, consult such persons and papers as may be necessary, and, as soon as practicable, shall advise me on the following subjects pertaining to the Department of Astronomical Observations:

(*a*) A general plan of work for the various instruments to cover a period of years.

(*b*) The number of observers required to employ all instruments to the best advantage, and the number of computers necessary to properly balance the force of observers. The apportionment of the work of reducing the observations between the observers and computers in such a way as to expeditiously prepare the observations for publication.

(*c*) The condition of all instruments and their availability for immediate use. If not available, in what respect and why. The extent to which instrumental errors have been investigated. The improvements needed to insure the most accurate observations.

(*d*) The status of work in connection with observations; their astronomical value and the sequence in which their reduction and publication should be undertaken.

(*e*) Any other subjects necessary to the efficiency of the astronomical work.

Very respectfully,

W. J. BARNETTE,
Captain, U. S. Navy, Superintendent Naval Observatory.

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Members of the board.—Commander A. G. Winterhalter, U. S. Navy, senior member; Professor of Mathematics Milton Updegraff, U. S. Navy, member; Professor of Mathematics W. S. Eichelberger, U. S. Navy, member; Professor of Mathematics F. B. Littell, U. S. Navy, member; Professor of Mathematics Asaph Hall, U. S. Navy, member.

The board began its work on May 11 and submitted its report on July 8.

Commander Winterhalter having been detailed as Hydrographer of the Navy, was detached from the observatory and Assistant Astronomer George A. Hill was made a member of the board to fill the vacancy.

The following are some of the more important conclusions and recommendations of the board and are approved by the Superintendent.

PLAN OF WORK.

The astronomical work of the Naval Observatory should be so planned and executed as to best subserve the two following purposes, to wit:

(*a*) To furnish to the Nautical Almanac Office, as far as may be possible, such observations and such data as may be needed for carrying out the purpose of the law under which the appropriations for that office are made from year to year, which is as follows: "For * * * preparing for publication the American Ephemeris and Nautical Almanac and improving the tables of the planets, moon, and stars * * *."

(*b*) To make such other observations for the promotion of astronomical science and geodesy and of navigation as may properly fall within the province of a great astronomical observatory maintained at government expense.

The principal work of this observatory should be in the field of the astronomy of position as distinguished from the astrophysical work which has attained in recent years such great development in the world and which is being so efficiently and so extensively carried on elsewhere in this country.

The instruments and methods used here and the selection and training of observers should be continuously and constructively adapted to the highest efficiency in the astronomy of position. In doing this, advantage should be taken of progress made in such work in this country and abroad. The methods should be adjusted to the present state of astronomy and to local conditions and should be, as far as possible, independent and original rather than imitative.

The so-called fixed stars being a system of points to which all other heavenly bodies are referred, the determination with the highest accuracy possible of the positions of these objects is of the utmost importance in astronomy. Since the fixed stars are subject to proper motion, the places of those which are used for the above purpose must be predicted with great accuracy for many years in advance. The so-called fundamental or standard stars are those whose past and present places are well enough known so that this can now be done. But unless the observation of these stars is continued, their predicted places will decrease in accuracy from year to year. Indeed, the places of few of them are as well determined as they should be even now, and besides the number of fundamental stars, ephemerides of whose apparent places are printed in the American Ephemeris from year to year should be increased, especially in certain parts of the sky.

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Therefore the main feature of a plan of work for this observatory should be the establishment and continued maintenance of meridian observations for absolute positions of the fundamental stars and of stars which are to be made fundamental, and in addition the independent determination by observations of the sun, of the position of the equator and equinox among the stars. The values of the constants of nutation and aberration on which all these operations depend should also be independently determined. Then determinations of the positions of the moon and planets with reference to the fundamental stars present few difficulties.

GENERAL PRINCIPLES GOVERNING FUNDAMENTAL WORK.

Determinations of positions of the heavenly bodies with reference to the equator and equinox, made in such a way as to be independent of other similar work, are to be regarded as fundamental or absolute in distinction from determinations of position merely with reference to the so-called fundamental or standard stars, which must be regarded as differential or relative.

In the execution of fundamental work, the observations should be so planned and so made as to give when reduced, as directly as possible, positions in both right ascension and declination of a fundamental or absolute character. Such observations may, if desired, be reduced in such a way as to give also differential results, but it is not advisable to make differential observations with a view to deducing therefrom fundamental results. Instrumental errors and errors in the adopted values of the constants of nutation and aberration as well as the variations of latitude and azimuth due to variability in the motion of the zenith point among the stars should be eliminated as far as possible in the processes of observation and reduction rather than by the application of numerical corrections.

Absolute determinations of declination must be made with reference to the equator point or to the polar point of the divided circle, and these points must be found by observations of the same circumpolar stars at both upper and lower culmination. The upper and lower culminations of any one circumpolar star observed should be as far as possible consecutive—that is, twelve hours apart. Since, in practice, the zero point, or rather the index of a divided circle, does not remain fixed for any considerable length of time, and because the observations of a circumpolar star at upper and lower culmination are at least twelve hours apart, some fixed point which can be observed directly, as the nadir point or the horizontal point, must be observed at the time of both upper and lower culmination. The mean of the two altitudes of the star derived from these observations may, when corrected for refraction, be regarded as a fundamental or absolute determination of the latitude of the place of observation. The latitude, when combined with the circle reading on either the nadir point or the horizontal point gives either the polar point or the equator point of the circle.

The difference between the circle reading for the equator point and the circle reading on any star on the meridian, the latter being corrected for refraction, gives a fundamental or absolute determination of the declination of the star. The atmospheric refraction at all zenith distances should be investigated by the best methods and fundamentally determined under conditions the same as those under which the above described observations are made.

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The equinoxes and the obliquity of the ecliptic are determined by means of fundamental observations of the declination of the sun. Then the right ascensions of a limited number of so-called fundamental or standard stars are determined by transit and clock observations of their distances in hour angle from the sun. These stars should be within perhaps 15° or 20° of the equator, and bright enough to be observed in the daytime. Then, by means of transit observavations with a clock of the best possible rate, the absolute right ascension of any other star or heavenly body may be determined. The clock rate must be determined by means of the same stars observed at consecutive transits. The clock error at any instant must be found from this rate, and from the error at some epoch based upon the known or assumed right ascensions of some or all of the above mentioned limited number of fundamental or standard stars.

In practice, an azimuth mark or mire is necessary for the best results. The azimuth of the mark, and indirectly that of the instrument, must be determined by observations of circumpolar stars at upper and lower culmination, the same stars being observed as far as possible at culminations which are consecutive. The collimation and level of the instrument will be obtained by the usual mechanical methods.

The constants of nutation and aberration should, of course, be independently determined, but so great is the accuracy of the values of these constants now in general use that any change in their adopted values must be regarded as inadvisable for the present. But approximate or provisional values of these constants would suffice for determination of the polar point and clock rate as above specified for the reason that they enter only in a differential manner. That is, the polar point and clock rate thus determined are affected by slight changes only, in the nutation and aberration, which can be accurately allowed for. The above-mentioned variability in the motion of the zenith point also has a slight differential effect on the position of the polar point and on the clock rate as determined, and also upon the azimuth of the mark.

The application of these principles will vary with the character of the work in hand and according to the individual views and practical methods of the observer. If it should appear to be desirable or necessary to modify this general plan for fundamental work, such change should be made only after due consideration and approval by a board which should act in the light of full knowledge both of the views of all the astronomers of this observatory and of the methods and the character of the results produced at the principal observatories of the world where meridian work is carried on.

It is the opinion of the board that Congress should be asked to appropriate for an assistant in the department of chronometers and time service.

In the opinion of the board the need for additional computers and observers is greater than that for additional equipment aside from such improvements in the present instrumental outfit as have been already recommended.

Furthermore, the efficiency of the entire force of the observatory would be materially increased by better accommodations for both lodging and meals on the observatory grounds. Additional quarters for observers are especially necessary. In this connection attention is called to the following quotation from the Report of the Chief of Bureau of Equipment for the year 1892, page 137, which is as true and as pertinent now as it was at that time:

"NOTE.—In order that the work of a large observatory may be properly and economically done, it is absolutely necessary that the observers be within prompt call to their instruments throughout day and night. Very important observations can often be

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secured from the clearing of the sky for a few hours, or even in some cases for a few minutes, if the observer be within easy call by the watchman. This can only be accomplished, in the isolated situation of the new observatory, by having dwellings upon the grounds for the observers. The Government erects dwellings at all its navy-yards, arsenals, forts, and schools for the officers on duty there. But no service requires such unremitting attention and constant presence at all hours as that of the astronomer, and no observatory can be regarded as economically managed which does not furnish dwellings for all its observers close by their instruments. It is estimated that with the observers living on the grounds of the new observatory not only will two or three times as much work be done as it will be possible to do otherwise, but the quality of this delicate work will be materially improved on account of the observers being in a proper physical condition to begin their labors, instead of with nerves unstrung from hurrying some miles from their homes immediately after meals, or at unreasonable hours of the night."

The value of the work and advice of this board were convincing proof that the astronomical work of the observatory could be more intelligently and uniformly administered with the advice of a body like the board, selected mainly from the astronomical staff of the observatory; therefore, following the general principles embodied in the recommendations of the Chief of Bureau of Equipment and Superintendent in their combined letter dated September 7, 1897, the following order was issued creating a council, believing that it would become an important element in the administrative machinery of the observatory and insure that continuity of policy and effort which is absolutely essential to its efficiency.

No. 1449.] U. S. NAVAL OBSERVATORY,
Washington, D. C., July 29, 1908.

ORDER.

There is hereby formed an astronomical council composed of the following members: The Superintendent (ex officio), the Assistant Superintendent, such assistants in charge of the astronomical divisions as the Superintendent may designate, and the Director of the Nautical Almanac.

The council should be guided by the fact that the most important astronomical duty of the Government is the publication of a nautical almanac, and as that is intended not only for the use of navigators, but also of astronomers in the most delicate investigations known to their science, it should be kept up to the highest attainable pitch of accuracy. To that end, continuous fundamental meridian observations upon the sun, moon, planets, and stars are absolutely necessary and constitute the astronomical essentials.

The council shall advise the Superintendent on the following subjects:

1. The coordination and cooperation of the work of the Department of Astronomical Observations and of the Nautical Almanac Office.
2. Suggested variations from the plan of astronomical work prescribed by regulations.
3. Methods to be used in the prosecution of the astronomical work.
4. Condition of and changes proposed in instrumental equipment.
5. The assignment of the scientific personnel to give the best possible results. The assignment of computers should be so made as to balance the work of the observers and computers, in order that observations may be expeditiously published.
6. The character and astronomical value of the observations and their publication.
7. Promotions, transfers, and filling of vacancies.
8. The yearly estimates for submission to the Secretary of the Navy.
9. The expenditure of the appropriations for astronomical and scientific purposes.
10. A system by which the cost of any piece of work may be readily available.

Of the above enumerated subjects, those relating to the Nautical Almanac Office shall be considered first by the director of that office, those relating to the Department of Astronomical Observations shall be considered first by an executive committee, and the conclusions of both shall be submitted to the council.

There shall be formed an executive committee of the council, consisting of three heads of divisions of the Department of Astronomical Observations, to be designated by the Superintendent.

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The executive committee shall have charge of all editing and printing pertaining to the Department of Astronomical Observations, and in addition shall undertake any other duties which may be assigned to it by the Superintendent or by the council.

The executive committee shall audit the accounts of the observatory arising from the expenditure of appropriations coming under the following subheads: Miscellaneous computations, Department of Astronomical Observations; professional and scientific books; apparatus and instruments and for repairs of same.

The heads of divisions of the Astronomical Department shall submit their monthly reports of progress to the Superintendent and these shall be laid before the council.

The council shall meet monthly, except in August, and at such other times as the Superintendent may direct.

A clerk shall be detailed to act as secretary of the council and of the executive committee, who shall keep minutes of each meeting in a book or other proper file.

Should the Superintendent not act on the advice of the council, he shall give his reasons therefor, and they shall be entered upon the minutes.

W. J. BARNETTE,
Captain, U. S. Navy, and Superintendent Naval Observatory.

The marked advantages of this new method of conducting the astronomical work of the observatory are already apparent, and if the above outlined plan of work and the council can be made permanent by proper regulations it is clear that the output from the observatory will in time fully meet the requirements of the Nautical Almanac and of astronomers.

As a result of the recommendations of the board, and with the approval of the council, measures have been taken to put the 6-inch transit circle in good working order, and if found suitable it will be employed in the determination of absolute positions of the sun and fixed stars, as recommended by the board.

It is intended, after thorough consideration and discussion by the council, to make other necessary improvements in the astronomical work of the observatory.

Abstracts of the reports of the heads of the various departments of the observatory follow:

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

From July 1 to August 21, 1907, this department was subdivided as shown in the Superintendent's last annual report. The Division of Equatorial Instruments was in charge of Prof. A. N. Skinner, U. S. Navy, until July 10, 1907, when at his own request he was relieved; the Division of Meridian Instruments was in charge of Prof. W. S. Eichelberger, U. S. Navy; the Division of the Alt-Azimuth Instrument was in charge of Prof. F. B. Littell, U. S. Navy; the Division of Prime Vertical Instrument was in charge of Assistant Astronomer G. A. Hill; and the Photographic Equatorial and Photoheliograph were in charge of Assistant George H. Peters.

On August 21, by order of the Superintendent, Prof. W. S. Eichelberger, U. S. Navy, was placed in charge of all observational work, and this arrangement has been continued to the end of the fiscal year.

THE 9-INCH TRANSIT CIRCLE.

Prof. W. S. EICHELBERGER, U. S. Navy, in charge.

This instrument has been used in the determination of the right ascensions and declinations of the sun, moon, planets, and the stars of Newcomb's Suggested List of Fundamental Stars. In addition, a

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few miscellaneous stars were observed and such zodiacal stars as were necessary to complete the four observations of each of those in the zodiacal list under observation for the past few years. Several hundred stars were observed for determination of personal equation and instrumental flexure. The instrument was used clamp east until April 23, and thereafter clamp west.

The number of observations from July 1, 1907, to June 30, 1908, is as follows:

Standard stars	6,585
Zodiacal stars	93
Miscellaneous stars	86
Screen stars for personal equation	297
Zenith stars for personal equation	259
Stars for instrumental flexure	84
Sun	169
Moon	155
Mercury	69
Venus	108
Mars	15
Jupiter	16
Saturn	12
Uranus	6
Neptune	15
Total	7,969

There are still needed about 1,000 observations to complete the 10 observations each of the stars in Newcomb's Suggested List of Fundamental Stars, but these observations are so scattered in right ascension that it will require about ten months to secure them.

In addition to the usual determinations of the horizontal and vertical flexure by use of collimators, a series of star observations, direct and reflected, in both clamps, was made, which gave results confirming those previously determined from the collimators.

The division error work, including the determinations of the correction for division error of each 2′ division of Circle B, was finished March 28, 1908. The probable error of the correction to the mean of four microscopes is 0.″04.

The reductions of the observations are further advanced than for several years past. The apparent declinations are finished to March, 1908, except the corrections for division error, flexure, and variation of latitude. The right ascensions are ready for the application of the clock correction up to October, 1907. The clock corrections are collected to September, 1907, and adopted to September, 1906. The reductions to mean place are computed to April, 1907.

The regular observers during the year have been Assistant Astronomer H. R. Morgan; Assistant (now Professor) Asaph Hall, to March 17, 1908; Assistant C. W. Frederick, from March 17, 1908; and Assistant (temporary appointment) Jesse Pawling, jr.

The observations of the zodiacal stars and of the stars for the determination of instrumental flexure were made by Prof. W. S. Eichelberger, U. S. Navy.

THE 6-INCH TRANSIT CIRCLE.

No observations have been made with this instrument during the past year. Various parts of the instrument, especially the pivots and circles, having deteriorated during the time which had elapsed since

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observations with it were discontinued on September 4, 1903, measures have been taken to put the instrument in good order for the determination of absolute positions of the sun and fixed stars.

During the year a wooden house to cover the south mark pier has been constructed.

THE CLOCKS.

The Riefler clocks in air-tight glass cases have continued to give satisfaction during the year. A definitive discussion of the rates of Riefler clock No. 70 from February 6 to June 21, 1905, has been completed. During this period the clock case was sealed and apparently no air entered or left the case, the changes that occurred in the pressure being due, presumably, to changes of temperature.

Assuming the clock rate to vary with the reading of the barometer in the clock case and with the time, the following expression was obtained from the observed rates for the daily rate of the clock:

$$R = +0^s.00254 - 0^s.01244\ (B - 677.5^{mm}) - 0^s.000365\ (T - \text{Apr. } 14.5).$$

The mean deviation of the computed from the observed daily rate for the period is $0^s.009$.

THE NEW CLOCK VAULT.

The construction of a shingle roof over this vault has stopped the leaking which had arisen through faulty construction. A new gas stove has been installed in the hot-water heating system and the amount of heating surface has been increased.

During June, 1908, the vault was kept closed and in all respects as it would be kept if the clocks were installed, except that no thermostat had yet been put in and the gas stove was in constant operation. At the end of the month, there was a difference of 6° F. between the wet and the dry bulb thermometers. The temperature in the corridor surrounding the vault and where the hot-water pipes are located had reached 98°.

Observations will be continued during the summer to see if the vault will remain sufficiently dry, and during the coming winter to determine if the heating plant is powerful enough to maintain a temperature of 75° in the vault throughout the entire year.

THE ALT-AZIMUTH.

Prof. F. B. LITTELL, U. S. Navy, in charge.

There were made with this instrument, used as a vertical circle, during July, 1907, 116 declination observations of stars in Newcomb's Suggested List of Fundamental Stars.

On July 17, 1907, the instrument was dismounted, preparatory to the construction of a new house for which Congress had appropriated $3,000. The new house embodies the latest ideas in the construction of a shelter for an instrument to be used for declination work, inasmuch as it leaves the instrument practically in the open air during observing. The roof sections move entirely off the building, leaving a free space 14 feet wide, with side walls only as

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high as the axis of the instrument, which act as a wind-break but do not prevent a distribution of air temperature conforming closely to that outside.

As stated in the last annual report, it was proposed to have the vertical circle of this instrument regraduated, and it was hoped that the regraduation could be done during the period the house was being built. However, it happened that the Warner & Swasey Company, the makers of this instrument, were moving their graduating engine, and it was not until March, 1908, that the circle was sent to them upon receipt of word that they were ready for the work. The circle has not yet been returned to the observatory. In order to do away entirely, if possible, with the troubles experienced in the use of silver divided strips, especially in connection with a steel circle, after considerable correspondence and some experimentation, it was decided to use a gold-silver alloy (80 per cent gold and 20 per cent silver) for the graduated surface and to copper-plate and then silver-plate the steel circle before inlaying the gold strip.

Prof. F. B. Littell, U. S. Navy, has been the only observer assigned to this instrument.

Since December, 1903, when Professor Littell commenced to observe with the alt-azimuth, he has made about 5,400 observations, and they are about one-half reduced at the present time.

Before December, 1903, Mr. Hill had accumulated 2,500 observations with this same instrument, but these are practically unreduced.

THE 26-INCH AND 12-INCH EQUATORIALS.

As stated above these instruments were under the general charge of Prof. A. N. Skinner, U. S. Navy, until July 10, 1907, and subsequently they were under the general charge of Prof. W. S. Eichelberger, U. S. Navy.

The number of observations from July 1, 1907, to June 30, 1908, with the 26-inch equatorial is as follows:

Satellites of Mars	18
Satellites of Saturn	189
Satellites of Uranus	29
Satellite of Neptune	13
Phenomena of Saturn's satellites	4
3 comets	15
58 asteroids	241
Double stars	4
Miscellaneous stars	3
Occultations of stars by moon	13
Total	529

The reduction of the observations is practically up to date. The observations of the satellites of Saturn and of the satellite of Neptune, as well as those of the satellites of Uranus made in 1907, have been communicated to the astronomical journals for publication. The printer's copy for a volume to include all the equatorial observations from 1894 to 1907, inclusive, is nearly completed.

Determinations of the orbits of several asteroids have been made during the year.

An electric motor for turning the dome has been installed, and works very satisfactorily.

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On May 20, 1908, the object-glass of the 26-inch equatorial was removed from its cell, cleaned, replaced, and adjusted by Mr. C. A. R. Lundin.

The observers during the year have been Prof. H. L. Rice, U. S. Navy, to September 21, 1907; Prof. Asaph Hall, U. S. Navy, from March 20, 1908; Assistant Astronomer J. C. Hammond and Assistant Matt Frederickson throughout the year.

The number of observations secured with the 12-inch equatorial from July 1, 1907, to June 30, 1908, is as follows:

13 asteroids	39
2 comets	5
Occultations of stars by moon	14
Phenomena of Saturn's satellites	3
Total	61

These observations were made by Assistant Matt Frederickson, except three comet observations by Assistant Astronomer H. L. Rice, and the phenomena of Saturn's satellites by Assistant George H. Peters.

On May 20 and 21, 1908, the object-glass of the 12-inch equatorial was removed from its cell, cleaned, replaced, and adjusted by Mr. C. A. R. Lundin.

The number of visitors received by permit during the year for a view of the heavens with the 12-inch equatorial is 1,708.

THE PRIME VERTICAL TRANSIT INSTRUMENT.

Assistant Astronomer G. A. HILL, in charge.

As in previous years Mr. Hill has been the only observer on this instrument during the year.

The same method has been used in observing with this instrument as has been outlined in former reports, i. e., to observe for variation of latitude, 16 stars, divided into four groups of four stars each, the mean right ascensions of the four groups being six hours, fourteen hours, eighteen hours, and twenty-two hours. The instrument is in good working order, and only a few minor repairs have been necessary. There were made during the year 599 observations.

The observations already made are reduced, checked, and transcribed on the printer's copy to January 1, 1906. The observations are reduced to mean place to October 25, 1907.

THE PHOTOGRAPHIC EQUATORIAL AND PHOTOHELIOGRAPH.

Assistant GEORGE H. PETERS, in charge.

The photographic equatorial was described in the Superintendent's annual report for the fiscal year ending June 30, 1905. In March, 1908, there was added to its battery of cameras an 8½-inch visually corrected lens of 12 feet focal length. This lens was the one used in the transit circle at the old observatory. All the work necessary to the mounting of this lens was done by Mr. Peters.

The instrument has been employed principally for finding asteroids to be observed micrometrically either with the 26-inch equatorial or the 12-inch.

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Eighty asteroid fields have been photographed with this instrument during the year, in some cases several asteroids being found on the same plate.

The sun has been photographed with the photoheliograph on one hundred and seventy-nine days, and solar spots were observed on every day but two. The photographs show a considerable decrease both in the number and in the size of the solar spots and groups. The total number of solar negatives now on hand made with this instrument is 1,634.

Mr. Peters has worked without assistance on these instruments.

THE TRANSIT OF MERCURY.

Four observations each of the III and IV contacts of the transit of Mercury were obtained on the morning of November 14 by Prof. W. S. Eichelberger, Assistant Astronomer G. A. Hill, Assistant Astronomer J. C. Hammond, and Assistant Matt Frederickson. Twelve photographs of the transit were obtained by Assistant G. H. Peters.

THE PARTIAL SOLAR ECLIPSE.

Five observations each of the I and II contacts of the partial solar eclipse were obtained on June 28 by Prof. F. B. Littell, Assistant Astronomer G. A. Hill, Assistant Astronomer J. C. Hammond, Assistant C. W. Frederick, and Assistant Matt Frederickson. Seven photographs of the sun during the eclipse were obtained by Assistant G. H. Peters.

ASTRONOMISCHE GESELLSCHAFT ZONE CATALOGUE —13° 50′ TO —18° 10′.

The printer's copy of this catalogue and the introduction was sent October 21, 1907, to Doctor Ristenpart, Berlin, Germany, who has charge of the publication for the Gesellschaft. The proof sheets were read both by Doctor Ristenpart and the Naval Observatory, and the last sheets were returned to Berlin May 27, 1908. It is expected that the completed volume will be published by the Astronomische Gesellschaft of Leipzig, Germany, during August, 1908.

This catalogue contains 8,824 stars observed by Prof. A. N. Skinner on the 9-inch transit circle 1894–1905, and forms the fourth volume of the second division of the catalogue of the Astronomische Gesellschaft which embraces all stars to the ninth magnitude between 23° south and 80° north declination.

Professor Skinner is now engaged in preparing material to be used in discussing the proper motions of the stars in this catalogue. This material is intended to embrace the data from all accessible star catalogues.

THE WASHINGTON ZONE CATALOGUE. 1846–1852.

All of the published observations have been compared with the Cordoba General Catalogue, and where there were sufficient stars in common, zone corrections have been deduced and applied.

The 5,000 errors furnished from different sources as mentioned in the annual report for the fiscal year ending June 30, 1903, and many

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others discovered during the last five years, have been examined and the necessary corrections to the observations made. During this work it was found that frequently transit threads which gave quite discordant results when reduced to mean thread were combined to give the published right ascension of the star, so that it was decided to re-reduce all transits. This has been finished for the transit and meridian circle zones, and is in progress for the mural zones. This investigation has revealed a large number of discordant threads.

The reduction of the 7,000 unpublished observations of 1847, 1848, 1851, and 1852 by Professor Littell is nearly completed, and a large part of these observations has been compared with the Cordoba General Catalogue in order to obtain the zone corrections.

DISCONTINUANCE OF THE BRANCH OBSERVATORY AT TUTUILA, SAMOA.

The branch observatory at the naval station, Tutuila, Samoa, established by an order of the Navy Department dated February 8, 1904, and intended for astronomical and magnetic work, was discontinued by an order of the department dated January 28, 1908. This was done for the reason that the climatic and terrestrial conditions have been found by practical experience to be such that there is no hope that the expectations with which that observatory was established could ever be realized.

Mr. C. W. Frederick, assistant U. S. Naval Observatory, was in charge of the Tutuila Observatory from September, 1904, to October, 1906, and Mr. Benjamin Boss, also an assistant here, was in charge from the latter date until the observatory was closed in May, 1908.

The reports of Mr. Frederick and of Mr. Boss, which are on file here, agree in showing that high winds, dense clouds, bad seeing, and an almost total absence of really clear weather, together with instability of the foundations of the observatory due probably to the beating of the waves on the seashore, rendered the site unsuitable for astronomical observations. The magnetic character of the volcanic formation of the island makes the site equally unsuitable for magnetic observations, and the existence of an active magnetic observatory maintained by the German Government on the neighboring island of Apia renders such observations unnecessary at Tutuila.

The closing of this observatory is further justified by the fact that the instrumental equipment both for astronomical and magnetic work was inadequate, and the conditions for living there were so unfavorable as to make necessary so frequent an exchange of observers as to impair whatever efficiency the observatory might otherwise have had.

PUBLICATIONS.

As showing the contributions to astronomy in general in other than government publications, the following list of articles made public is submitted:

In the *Astronomische Nachrichten*, Nr. 4226: "Ephemeris of minor planet (611) (1906 VL)," by Matt Frederickson.

In the *Astronomische Nachrichten*, Nr. 4232: "Asaph Hall," by W. S. Eichelberger.

In the *Astronomische Nachrichten*, Nr. 4234: "Elements and finding ephemeris of planet 1906 VM," by Eleanor A. Lamson.

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In the *Astronomische Nachrichten*, Nr. 4240: "Ephemeris of minor planet (622) (1906 WP)," by Matt Frederickson.

In the *Astronomische Nachrichten*, Nr. 4245: "Elements and ephemeris of (581) Tauntonia," by H. [illegible]. Morgan.

In the Astronomical Journal, No. 596: "Elements of planet 1907 XZ," by Eleanor A. Lamson.

In the Astronomical Journal, No. 598: "Elements and ephemerides of planet 1907 XP," by Asaph Hall, jr.

In the Astronomical Journal, No. 599: "Elements and ephemeris of comet *d* 1907 (Mellish)," by Eleanor A. Lamson.

In the Biographical Memoirs of the National Academy of Sciences, Vol. VI, pp. 276–309: "Published writings of Asaph Hall," by W. D. Horigan.

In the Veröffentlichungen des Königlichen Astronomischen Rechen-Instituts zu Berlin, No. 32: "Elements and ephemeris of 599 (1906 VI)," by Matt Frederickson.

Also in the Astronomical Journal and Astronomische Nachrichten numerous observations of satellites, asteroids, and comets, and the observations of the transit of Mercury, November 14, 1907.

THE NAUTICAL ALMANAC OFFICE.

This office continued under the direction of Prof. W. S. Harshman, U. S. Navy, until October 1, 1907, when he was succeeded by Prof. Milton Updegraff, U. S. Navy.

On July 1, 1908, Mr. James Robertson was advanced from assistant at $1,600 to assistant at $1,800 to fill a position at that salary established by Congress this year. Mr. G. F. Crawley, of Columbia, S. C., was appointed a piecework computer on December 19, 1907. On February 12, 1908, Miss Isabel Martin, of Washington, D. C., was appointed a piecework computer by transfer from the eligible list for miscellaneous computer, U. S. Naval Observatory. Mr. Thomas E. Trott, of Scio, Ohio, was appointed piecework computer on June 15, 1908.

The duty of distributing the American Ephemeris and Nautical Almanac and the American Nautical Almanac to the ships of the navy has been transferred by the Chief of the Bureau of Equipment from the Hydrographic Office of the Navy to the Nautical Almanac Office, beginning with the issues of these publications for the year 1909.

The list of astronomical observatories and of other institutions both domestic and foreign to which the American Ephemeris and Nautical Almanac and the Astronomical Papers are sent has been considerably increased. The number of astronomers and of other persons of scientific reputation and standing to whom the Astronomical Papers are sent free has been largely increased, but, with the exception of a very few cases, the American Ephemeris and Nautical Almanac is not sent free to individuals.

As stated in the last report, all of the publications of the office, including the Astronomical Papers of the American Ephemeris, Volumes I to VIII, are kept for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. They are no longer sold by the Nautical Almanac Office. Volume I of the Astronomical Papers has been out of print in this country for some years, but 107 copies belonging to the office have recently been procured from certain booksellers in Europe to whom they had been sent in 1882 to be

sold, and are now for sale by the Superintendent of Documents, as noted above.

Two parts of Volume IX of the Astronomical Papers of the American Ephemeris, entitled "Tables of the Satellites of Saturn," and "Tables for the Transformation of Longitude and Latitude into Right Ascension and Declination for the Sun and Moon," which have been prepared during the past few years, are ready for the press. Their publication has been delayed by a deficiency in the printing fund of the Navy Department for the last fiscal year. The material for a third part of Volume IX is now being prepared.

A considerable amount of work is being done by the office in cooperation with Prof. Simon Newcomb, U. S. Navy (retired), in continuation of his researches on the motions of the Moon and the planet Mars, which were commenced while Professor Newcomb was Director of the Nautical Almanac.

The American Ephemeris and Nautical Almanac for the year 1911 was distributed in April, 1908. It differs only slightly from the issues for several years past, but preparations are being made for various changes in the volume for the year 1912, some of the more important of which are as follows:

(*a*) The tables of lunar distances will be omitted hereafter. Inquiries made in October, 1907, by the Chief of the Bureau of Equipment, developed the fact that these tables are practically no longer used by the navigators of either the naval service or of the merchant marine, and authority has been given for their omission beginning with the volume for 1912.

(*b*) The omission of the lunar-distance tables will make available for other matter about 74 pages of the American Ephemeris and Nautical Almanac, and this space will be utilized by increasing by about 300 the number of ephemerides of fixed stars, thus raising the total number of such stars of which the apparent places are given to about 700. These stars and their mean places in right ascension and declination for the beginning of the year are taken from Newcomb's Fundamental Catalogue.

(*c*) Beginning with the volume for the year 1912, the constants of precession, nutation, and aberration and the obliquity of the ecliptic adopted by the Paris conference of 1896 will be used instead of the Struve-Peters values of these constants which have been used hitherto in the body of the book.

(*d*) The increased speed within recent years of vessels both of the navy and of the merchant marine makes necessary an increased use of observations of the fixed stars and of the planets, especially in connection with Sumner's Method. In order to make such observations more convenient, a pamphlet containing monthly lists of bright stars and planets with their positions and other data for the year 1908 was prepared in the Nautical Almanac Office in November, 1907, and was issued in December to the ships of the navy, including the vessels of the fleet before it sailed from Norfolk, Va., on December 16. This was done by way of experiment, and if they are found to be of practical value these monthly lists, together with certain auxiliary tables, will be incorporated in the American Nautical Almanac for 1912 and for subsequent years.

There have been received during the year from the Government Printing Office 904 copies of the American Ephemeris and Nautical Almanac for 1908, second edition: 3,500 copies of the American Nau-

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tical Almanac for 1908, second edition; 500 copies of Stars for Navigators for 1908 (supplement to the American Ephemeris and Nautical Almanac for 1908, first edition), and 1,550 copies second edition; 1,000 copies of the American Ephemeris and Nautical Almanac for 1911, first edition; 500 copies of the American Nautical Almanac for 1911, first edition.

The distribution of the publications of the Nautical Almanac Office during the year is shown in the following table:

	Naval service.	Other departments.	Superintendent of documents.	Free distribution.	Total.
American Ephemeris and Nautical Almanac	544	336	1,000	647	2,527
American Nautical Almanac	424	35	4,089	.....	4,548
Astronomical Papers	.....	.....	28	819	847
Stars for Navigators	846	31	510	94	1,481

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

The department was in charge of Commander T. D. Griffin, U. S. Navy, until August 8, 1907, when he was detached for duty as commanding officer, U. S. S. *Paducah;* Commander A. G. Winterhalter, U. S. Navy, was in charge of the department from September 9, 1907, to May 17, 1908, when he was detached and placed in charge of the Hydrographic Office. Assistant E. A. Boeger was in charge during the remainder of the fiscal year.

The following is a brief summary of the work of this department during the fiscal year:

Value of stock on hand July 1, 1907	$100,000.00
Value of instruments, etc., purchased	$48,133.37
Value of articles received from navy-yards, etc.	$126,209.83
Value of articles issued	$150,205.84
Value of stock on hand June 30, 1908	$124,137.36
Number of shipments made	506
Number of instruments, etc., shipped	5,698

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department was in charge of Commander E. E. Hayden, U. S. Navy.

The regular annual chronometer trial began January 6, 1908, and ended June 8, 1908. The total number of instruments under trial, the largest on record, was as follows: Thirty-five new chronometers, 38 new torpedo-boat watches, 103 old naval chronometers, 14 old torpedo-boat watches, 6 chronometer watches, 4 comparing watches, and 7 sample watches of various types, a grand total of 207.

The accompanying tabular statements, Tables I, II, and III, give all the data and results of the trial for those instruments that were received in time and that obtained a trial number of 25 or less.

The regular work of the department in connection with the rating and issue of chronometers, the testing of new chronometers, watches, and clocks, and the sending out of the daily telegraphic time signals has been heavier than usual during the year.

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The mean daily error of the noon signal for the year was $0^s.054$, the maximum error on any day being $0^s.36$.

In connection with the New Year's Eve telegraphic time signals, which were sent out as usual, it is of interest to note the fact that their apparent receipt at the Mare Island Navy-Yard $0^s.36$ too early resulted in a redetermination of the longitude of that observatory by the exchange of observers and telegraphic signals with Lick Observatory. The former accepted value, $8^h\ 09^m\ 05^s.29$, was thus changed to $8^h\ 09^m\ 05^s.63$ west from Greenwich. The close agreement of the error, $0^s.34$, with that indicated by the too early receipt of our time signals, $0^s.36$, is a remarkable confirmation of the rapidity and accuracy with which our signals were transmitted across the continent by the Western Union Telegraph Company, which also sends them daily to all of the naval time-ball stations.

COMPASS OFFICE.

The personnel of the office has been as follows: From July 1, 1907, to March 18, 1908, Commander Thomas Snowden, U. S. Navy, superintendent of compasses; from March 1, 1908, to March 18, 1908, Lieut. Commander J. S. Doddridge, U. S. Navy, assistant; from March 18, 1908, to June 30, 1908, Lieut. Commander J. S. Doddridge, U. S. Navy, superintendent of compasses.

LIBRARY.

	Volumes.	Pamphlets.	Total.
Contents of library July 1, 1907	20,912	4,369	25,281
Accessions	563	84	647
Contents July 1, 1908	21,475	4,453	25,928

Of the accessions, 364 were received as exchanges and 283 were purchased. There were distributed 1,110 copies of the various publications of the observatory. The routine work is up to date.

The observatory has been much inconvenienced in its administrative functions through the need of certain, usually considered necessary, works of reference. For example, owing to various decisions of the Comptroller of the Treasury, the observatory can not pay for the Directory of the District of Columbia out of any of its present funds.

BUILDINGS, GROUNDS, AND ROADS.

All buildings except the main building are in good condition. An appropriation was made for the necessary repairs on the main building, and this work will be completed the coming fall.

The roads have been kept in repair and 450 feet of new concrete walk has been laid.

The high bank on Massachusetts avenue has been graded and a deep ravine on the north side of the grounds filled so as to make a new road of easy grade to Massachusetts avenue.

The following improvements have been made in the sewerage system: All cesspools have been filled up and 1,400 feet of new sewer pipe laid and connected with the District system.

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cation No. 16 C 1, of April 30, 1907), United States Naval

eter room. (Orientation changed for polarity test, one week on E., W., S., and N.)

.59	69.32	69.80	69.53	65.31	67.62	69.56	75.00	71.12
18	43	54	50	55	60	73	74	67
r. 6 to r. 13.	Apr. 13 to Apr. 20.	Apr. 20 to Apr. 27.	Apr. 27 to May 4.	May 4 to May 11.	May 11 to May 18.	May 18 to May 25.	May 25 to June 1.	June 1 to June 8.
s.	s.	s.	s.	s.	s.	s.	s.	s.
+1.66	−1.69	−1.73	−1.86	−1.80	−1.67	−1.49	−1.33	−1.51
+2.01	−1.99	−2.00	−2.07	−2.10	−1.97	−1.90	−1.74	−1.83
+0.74	+0.73	+0.63	+0.63	+0.44	+0.59	+0.76	+0.97	+0.67
+0.01	−0.06	−0.24	−0.19	−0.33	−0.29	−0.21	−0.01	−0.23
+0.09	−0.11	−0.19	−0.09	−0.03	+0.09	−0.04	−0.23	−0.40
+0.69	+0.54	+0.41	+0.24	+0.19	+0.43	+0.76	+0.99	+0.74
+0.20	−0.26	−0.20	−0.29	−0.29	−0.19	+0.07	+0.37	+0.30
+1.47	−1.29	−1.39	−1.39	−1.29	−1.33	−1.01	−0.73	−0.87
+0.13	−0.11	−0.13	−0.23	−0.39	−0.13	+0.40	+0.60	+0.34
+1.33	−1.44	−1.53	−1.59	−1.69	−1.49	−1.64	−1.71	−1.47
+1.26	−1.33	−1.61	−1.31	−0.87	−1.33	−1.43	−1.27	−1.63
+0.14	−0.11	−0.14	−0.16	−0.30	0.00	+0.19	+0.51	+0.41
+2.81	+2.46	+2.41	+2.07	+2.33	+2.57	+2.80	+2.96	+2.97
+1.73	−1.84	−1.97	−1.80	−1.41	−1.43	−1.17	−1.14	−1.36
+0.09	−0.16	−0.30	−0.53	−0.46	−0.37	+0.33	+0.57	+0.50
+0.04	−0.10	−0.24	−0.24	+0.24	+0.29	+0.24	−0.01	−0.40

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TA*val Observatory, Washington, D. C., January 6 to June 8, 1908.*

eter room. (Orientation changed for polarity test, one week on E., W., S., and N.)

T	59	69.32	69.80	69.53	65.31	67.62	69.56	75.00	71.12
R	8	43	54	50	55	60	73	74	67
Order of work	r. 6 to . 13.	Apr. 13 to Apr. 20.	Apr. 20 to Apr. 27.	Apr. 27 to May 4.	May 4 to May 11.	May 11 to May 18.	May 18 to May 25.	May 25 to June 1.	June 1 to June 8.
	s.	s.	s.	s.	s.	s.	s.	s.	s.
1	0.37	−0.31	−0.33	−0.01	−0.14	−0.44	−0.34	−0.14	−0.41
2	1.07	+1.16	+0.99	+1.11	+0.91	+1.31	+1.40	+1.79	+1.57
3	0.13	−0.24	−0.50	−0.51	−0.53	−0.14	−0.21	+0.04	−0.17
4	0.91	−0.84	−0.91	−0.73	−0.83	−0.59	−1.13	−0.87	−0.66
5	0.80	−0.59	−0.76	−0.80	−0.73	−0.96	−0.34	−0.23	−0.13
6	0.64	+0.60	+0.59	+0.67	+0.81	+0.96	+0.87	+0.84	+0.94
7	2.67	+2.71	+2.80	+2.93	+3.26	+2.83	+2.66	+2.49	+2.84
8	3.16	−3.16	−3.41	−3.44	−3.26	−3.07	−2.73	−2.46	−2.57
9	0.74	−0.94	−1.06	−0.83	−0.81	−0.89	−0.16	+0.04	−0.39
10	4.67	−4.90	−5.01	−4.11	−4.70	−4.91	−4.17	−3.87	−4.26
11	0.90	+1.09	+1.11	+1.50	+0.93	+0.89	+1.23	+1.56	+1.14
12	0.89	+1.07	+1.17	+0.20	+0.37	+0.47	+0.47	+0.89	+1.16
13	0.73	+1.14	+0.83	+0.73	+0.76	+1.06	+0.29	+0.49	+0.70
14	2.09	−2.04	−2.04	−2.13	−2.41	−1.87	−2.03	−1.50	−0.74
15	2.90	−2.97	−2.76	−2.84	−2.93	−2.64	−2.34	−2.24	−3.01
16	1.04	+0.90	+0.94	+1.03	+1.00	+0.81	+1.53	+1.20	+0.54

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0. 29
1. 00
2. 47
0. 89
0. 86

1. 77
0. 17
0. 47
1. 73
1. 86

1. 69
0. 64

0. 61
0. 77
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1. 29
0. 16
1. 23
0. 73
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0. 84
1. 37

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eter room. (Orientation changed for polarity test, one week on E., W., S., and N.)

.59	69.32	69.80	69.53	65.31	67.62	69.56	75.00	71.12	
18	43	54	50	55	60	73	74	67	
r. 6 to r. 13.	Apr. 13 to Apr. 20.	Apr. 20 to Apr. 27.	Apr. 27 to May 4.	May 4 to May 11.	May 11 to May 18.	May 18 to May 25.	May 25 to June 1.	June 1 to June 8.	
.	s.	s.	s.	s.	s.	s.	s.	s.	
3.94	+4.07	+3.90	+3.74	+3.84	+4.07	+4.21	+3.91	.....	
2.03	−2.03	−2.33	−1.93	−2.34	−1.91	−2.20	−2.07	.....	
1.60	+1.56	+1.40	+1.47	+1.37	+1.24	+1.27	+1.46	.....	
0.03	−0.03	−0.21	−0.23	−0.24	−0.30	−0.47	−0.29	.....	
0.44	+0.64	+0.31	+0.44	+0.59	+0.41	+0.21	−0.03	.....	
1.39	+1.31	+1.39	+1.26	+1.17	+1.31	+1.47	+1.74	.....	
0.16	−0.16	−0.27	+0.03	−0.30	−0.34	−0.47	−0.33	.....	
0.33	−0.50	−0.63	−0.64	−0.73	−0.56	−0.76	−1.06	.....	
0.84	−0.81	Issued to the Chester.							
2.47	+2.41	+2.34	+2.41	+2.50	+2.50	+2.56	+4.99	.....	
0.56	+0.67	+0.66	+0.40	+0.39	+0.03	+0.46	+0.59	.....	
1.37	−1.29	Issued to the Chester.							
0.29	+0.19	Issued to the Chester.							
1.00	+0.93	+0.91	+0.89	+0.63	+0.81	+0.80	To New Hampshire.		
2.47	+2.26	+1.90	+2.09	+1.69	+1.56	+1.86	+2.11	.....	
0.89	+0.77	+0.79	+0.70	+0.64	+0.70	+0.94	+1.20	.....	
0.86	−0.89	−0.91	−0.91	−0.81	−0.86	−0.93	−0.91	.....	
1.77	+1.61	Issued to the Birmingham.							
0.17	−0.23	−0.34	−0.39	−0.39	−0.54	−0.69	−0.47	.....	
0.47	+0.51	+0.59	+0.61	+0.91	+0.63	+0.60	+0.87	.....	
1.73	+1.66	+1.61	+1.69	+2.20	+1.74	+1.73	+1.71	.....	
1.86	+1.84	+1.83	+1.79	+1.86	+1.94	+2.07	+2.40	.....	
1.69	+1.56	+1.54	+1.50	+1.69	+1.63	+1.76	+1.86	.....	
0.64	+0.47	+0.39	+0.26	+0.27	+0.40	+0.74	+0.94	.....	
0.61	−0.56	Issued to the Birmingham.							
0.77	+0.86	+0.73	+0.81	+0.86	+0.74	+0.66	+0.76	.....	
0.51	−0.61	−0.50	−0.44	−0.60	−0.39	Issued to the Chicago.			
1.29	+1.26	+1.11	+1.14	+0.97	+1.06	+0.99	+1.20	.....	
0.16	−0.31	−0.40	−0.33	−0.19	−0.27	−0.23	−0.34	.....	
1.23	+1.47	+1.53	+1.30	+1.46	+1.57	+1.71	+1.01	.....	
0.73	+0.73	+0.64	+0.63	+0.69	+0.64	+0.61	+0.87	.....	
0.70	+0.53	+0.53	+0.56	+0.50	+0.74	+1.10	+1.34	.....	
0.84	+0.86	+1.06	+0.74	+0.66	+0.70	Issued to the Chicago.			
1.37	+1.30	+1.30	+1.27	+1.39	+1.41	+1.21	+1.20	.....	
1.73	−1.83	−2.09	−2.13	Issued to the Newark.					
0.51	+0.61	+0.60	+0.60	−1.87	−2.09	−1.94	−2.04	.....	
2.60	−2.74	Issued to the Birmingham.							
1.43	+1.37	+1.31	+1.06	+1.11	+0.83	+1.06	+1.13	.....	
0.24	+0.11	+0.01	+0.04	+0.14	+0.30	+0.30	+0.40	.....	
2.14	+2.06	+1.89	+1.86	+1.83	+1.64	+1.69	+1.84	.....	
0.56	+0.51	+0.43	+0.43	+0.54	+0.30	+0.46	+1.11	.....	
0.59	+0.51	+0.33	+0.44	Issued to the Idaho.					
1.40	+1.56	+1.09	+1.01	+0.59	+0.53	+0.40	+0.70	.....	
3.04	−3.09	−3.24	−3.27	+0.96	+0.71	To North Carolina.			
2.97	+3.07	+3.19	+2.80	−3.69	−3.57	−3.67	−3.01	.....	
0.99	−0.91	−1.33	−1.27	+2.97	+3.03	+2.80	To Machias.		
2.14	+2.43	+2.44	+2.41	−1.56	−1.54	−1.30	−0.94	.....	
0.21	+0.13	−0.27	−0.06	+2.34	+2.23	+2.13	+2.01	.....	
0.94	−0.87	−1.19	−1.24	−0.69	0.00	+0.60	To New Hampshire.		
0.81	−1.07	−1.26	−1.36	−1.07	−1.23	To the North Carolina.			
2.36	+2.30	+2.13	+2.16	−1.21	−1.41	−1.20	−1.20	.....	
0.81	+0.76	+0.66	+0.49	+2.20	+2.19	+2.01	+1.74	.....	
2.11	+2.07	+2.03	+1.91	+0.04	+0.31	+0.63	+1.34	.....	
2.00	−2.86	−2.50	−3.04	+2.41	+1.59	+1.47	+1.56	.....	
0.86	−0.87	−0.94	−1.39	−3.03	−2.87	−3.30	−3.31	.....	
0.10	+0.09	+0.09	−0.20	−1.37	−0.89	−0.36	−0.06	.....	
0.80	−0.94	−1.07	−1.11	−0.29	−0.44	−0.14	+0.14	.....	
0.51	−0.59	−0.60	−0.54	−1.36	−1.20	To the Hartford.			
0.13	−0.06	−0.34	−0.43	−0.59	−0.29	+0.06	+0.33	.....	
1.26	+1.04	+0.91	+0.93	−0.37	−0.30	−0.37	−0.24	.....	
1.53	−1.10	−1.37	−1.63	+0.70	+0.56	+0.91	+1.46	.....	
0.30	+0.29	+0.09	−0.14	−1.07	−1.67	−1.03	−0.54	.....	
0.46	−0.56	−0.71	−0.69	−0.01	+0.03	+0.16	+0.11	.....	
				−1.11	−0.97	−0.66	−0.04	.....	

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NAVY DEPARTMENT

UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1909

GOVERNMENT PRINTING OFFICE
WASHINGTON
1910

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SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1909.

Rear-Admiral W. J. Barnette, U. S. Navy, continued as Superintendent until his death on April 19, 1909. Capt. T. E. De Witt Veeder, U. S. Navy, assumed the duties of Superintendent on April 20, 1909.

In March, 1909, the Secretary of the Navy issued the following instruction with regard to the methods, purposes, and scope of work of this institution:

The following order of the Superintendent of the United States Naval Observatory, organizing the astronomical council and defining its duties, together with certain features of the plan of astronomical work now in force there, are hereby established as a part of the administrative system of that institution.

U. S. NAVAL OBSERVATORY,
Washington, D. C., July 29, 1908.

ORDER.

There is hereby formed an astronomical council composed of the following members: The Superintendent (ex officio), the Assistant Superintendent, such assistants in charge of the astronomical divisions as the Superintendent may designate, and the Director of the Nautical Almanac.

The council should be guided by the fact that the most important astronomical duty of the Government is the publication of the Nautical Almanac, and as that is intended not only for the use of navigators, but also of astronomers in the most delicate investigations known to their science, it should be kept up to the highest attainable pitch of accuracy. To that end, continuous fundamental meridian observations upon the sun, moon, planets, and stars are absolutely necessary and constitute the astronomical essentials.

The council shall advise the Superintendent on the following subjects:

1. The coordination and cooperation of the work of the Department of Astronomical Observations and of the Nautical Almanac Office.
2. Suggested variations from the plan of astronomical work prescribed by the regulations.
3. Methods to be used in the prosecution of the astronomical work.
4. Condition of and changes proposed in instrumental equipment.
5. The assignment of the scientific personnel to give the best possible results. The assignment of computers should be so made as to balance the work of the observers and computers, in order that observations may be expeditiously published.
6. The character and astronomical value of the observations and their publication.
7. Promotions, transfers, and filling of vacancies.
8. The yearly estimates for submission to the Secretary of the Navy.
9. The expenditure of the appropriations for astronomical and scientific purposes.
10. A system by which the cost of any piece of work may be readily available.

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Of the above-enumerated subjects, those relating to the Nautical Almanac Office shall be considered first by the director of that office, those relating to the Department of Astronomical Observations shall be considered first by an executive committee, and the conclusions of both shall be submitted to the council.

There shall be formed an executive committee of the council, consisting of three heads of divisions of the Department of Astronomical Observations, to be designated by the Superintendent.

The executive committee shall have charge of all editing and printing pertaining to the Department of Astronomical Observations, and in addition shall undertake any other duties which may be assigned to it by the Superintendent or by the council.

The executive committee shall audit the accounts of the observatory arising from the expenditure of appropriations coming under the following subheads: Miscellaneous computations, Department of Astronomical Observations; professional and scientific books; apparatus and instruments and for repairs of same.

The heads of divisions of the Astronomical Department shall submit their monthly reports of progress to the Superintendent, and these shall be laid before the council.

The council shall meet monthly, except in August, and at such other times as the Superintendent may direct.

A clerk shall be detailed to act as secretary of the council and of the executive committee, who shall keep minutes of each meeting in a book or other proper file.

Should the Superintendent not act on the advice of the council, he shall give his reasons therefor, and they shall be entered upon the minutes.

W. J. BARNETTE,
Captain, U. S. Navy, and Superintendent Naval Observatory.

The astronomical work of the Naval Observatory shall be so planned and executed as best to subserve the following purposes, and no others, to wit:

To furnish to the Nautical Almanac Office, as far as may be possible, such observations and such data as may be needed for carrying out the purpose of the law under which the appropriations for that office are made from year to year, which is as follows:

For * * * preparing for publication the American Ephemeris and Nautical Almanac and improving the tables of the planets, moon, and stars * * *.

The principal work of the observatory shall be in the field of the astronomy of position as distinguished from astrophysical work, and shall be the continued maintenance of observations for absolute positions of the fundamental stars and of stars which are to be made fundamental, and in addition the independent determination by observations of the sun, of the position of the ecliptic, and of the equator among the stars, and of the positions of the stars, moon, and planets with reference to the equator and equinoxes.

(Signed) TRUMAN H. NEWBERRY,
Secretary.

The duties of the institution have been so arranged, that it is believed entirely satisfactory results will be attained, while the operations will move with a common purpose known to the entire staff. The council has held its regular meetings and special meetings for the consideration of matters requiring prompt action.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

DIVISION OF THE 6-INCH TRANSIT CIRCLE.

This division was in charge of Prof. M. Updegraff, U. S. Navy, except for the first four weeks of the fiscal year, when Prof. W. S. Eichelberger, U. S. Navy, was in charge.

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The Board of 1908 on Plan and Scope of Work submitted:

That the Superintendent be advised to have the pivots of the 6-inch transit circle reground, and the divided circles put in good condition, if possible without redivision, and to have such other repairs made as may be found to be necessary to put the instrument in good condition for fundamental work in both right ascension and declination in order that the instrument may be thoroughly and exhaustively tested for its fitness for such work.

In August, 1908, the instrument was dismounted and sent to The Warner & Swasey Co. for the work recommended. It was necessary to take off about 0.006 inches of the diameter of the pivots in order to remove all traces of rust spots. The pivots were then tested and found to be so regular in form as to be highly satisfactory. By January, 1909, the whole instrument was returned and mounted in the following month.

In addition to the above-mentioned repairs, Circle B was so fitted on its bearings on the axis that it can be conveniently rotated, but is at the same time held in position with sufficient firmness by friction. This arrangement has been found to be very satisfactory.

The holes in the pivots were enlarged from 1 to $1\frac{1}{4}$ inches in diameter, and an axial collimator lens of $1\frac{5}{16}$ inches clear aperture was provided. Numerous minor improvements in the instrument were made.

While the instrument was undergoing repairs, the brick piers were painted with two coats of asphalt varnish and covered with two layers of asbestos felt. They were then incased with cherry boards, dressed, tongued and grooved, and seven-eighths of an inch thick. This casing was fastened to, and is supported by, the piers themselves, and is separated from the floor of the building by a clear space of about one-fourth of an inch, which space is closed with felt weather strips to prevent circulation of air.

The silver strip, which is inlaid in the steel circles, and which bears the divisions, had become corroded by rust from the steel and was disfigured by a number of scratches, which in a number of cases affected the divisions. These circles were gone over and the damage repaired as far as was practicable.

The contact points of the transit micrometer, which had been too close together were changed so that the signals on the chronograph made in the observation of a star on the equator are 0^s.7 apart. There are 10 such signals, the middle being shown by a double space for the purpose of identification. It may be mentioned here that in June, 1909, the transit micrometer was returned to The Warner & Swasey Co. for rearrangement of the reticule of fixed wires, in order to make it convenient for observations of the sun, the moon, and the stars. In addition to this, repairs of the reticule which had become necessary were made.

The illumination of the field of the 6-inch transit circle, which had been changed in the year 1901 so as to illuminate the field by light reflected from a mirror cemented on the inner surface of the object-glass, was changed again a few years ago, the mirror being placed on the outside of the object-glass. After many futile attempts to adjust the illumination and make it satisfactory with this arrangement, it was found to be necessary, in March, to change back to the mirror on the inside of the object-glass. The light reflected from the mirror on the outside of the object-glass formed

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into an image in passing through in such a way that the diaphragm which regulates the brightness, instead of modifying the brightness of the general illumination, cut the light off from a portion of the field, leaving the remainder bright. The illumination of the field is now satisfactory and can be easily and quickly adjusted from great brilliance to total darkness.

The telescope was found to be imperfectly balanced, the object-glass end being too light, and on May 11 a lead weight weighing $4\frac{3}{8}$ ounces was fastened inside the object-glass end of the tube.

In June, when an attempt was made to bring the vertical collimator apparatus into use, it was found necessary to shorten the tube of the telescope by 2 inches in order to focus it.

The errors of the instrument have been partially investigated in the process of determining the fitness of the instrument for fundamental work, as required by the resolution of the Board of 1908 on Plan and Scope of Work, quoted above.

The spherometer caliper measures of the pivots have shown their form to be satisfactory, and the difference in size between the two pivots has been found to be inappreciable. The result thus found, as to the regularity of the form of the pivots, is confirmed by an elaborate series of observations with the axial collimator, by four observers. This work indicates that the axis of the instrument suffers no displacement, as the telescope revolves, which is large enough to cause any appreciable error in the observations in right ascension. The enlargement as noted above of the clear aperture of the axial collimator lens has improved the definition and hence the accuracy of the apparatus.

Two of the microscope micrometer screws have been investigated for periodic errors with the Transit of Venus measuring engine and the errors found are small. It remains to investigate the other screws.

The errors of the 15° lines of both divided circles have been very carefully measured by the method of comparison and will serve as a basis for determining the errors of other divisions of these circles. The results on the 15° lines are as follows:

$A_{15} = -0.89$	$B_{15} = -0.77$
$A_{30} = +1.00$	$B_{30} = +1.06$
$A_{45} = -0.03$	$B_{45} = -0.04$
$A_{60} = -0.24$	$B_{60} = +0.01$
$A_{75} = -0.91$	$B_{75} = -0.67$

The telescope of this instrument is subject to a change of focus with temperature, which has been carefully observed, and the focus has been adjusted when change of temperature has made it necessary. However, no serious inconvenience or error in the observations has resulted from the change of focus which has occurred. It seems probable that the adjustment of the focus of the telescope will not be needed oftener than two or three times a year.

The nadir point and the constants of azimuth, level, and collimation of the instrument are steady to a satisfactory degree. The instrument was adjusted in azimuth and level for the last time, as far as is known, in the year 1902. When the instrument was mounted last February these constants were found so small that no adjustment was necessary.

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In the observations of stars, as in the investigation of the errors of the instrument, the plan for fundamental work as formulated by the Board of 1908 on Plan and Scope of Work above mentioned is being carried out.

The observations of stars which have been made are given in the following table:

Inclination stars	60
Polaris U. C	24
Polaris L. C	34
Circumpolar stars other than Polaris for azimuth	39
Fundamental stars near autumnal equinox (10 in group)	290
Other stars from American Ephemeris and Newcomb's Fundamental Catalogue	1,473
Total number of observations	1,920

Twenty observations of Polaris U. C. and L. C. twelve hours apart have been made.

The reduction of these observations is practically up to date, but little has been done in discussing them.

The following probable errors have been deduced from observations made from March 15 to March 22: In right ascension, with the new transit micrometers, $+0^s.020$ sec.δ; in declination for Circle A, $+0''.27$; for Circle B, $+0''.64$. The large probable error of Circle B is mainly due to the effect of division errors, which will be removed when the corrections for division errors are applied.

It is expected that very soon the efforts of the staff of this division may be wholly devoted to the fundamental work which is the duty to which it is expected to assign this instrument. At a meeting of the council of June 23, 1909, was considered a plan of work for the fiscal year 1910, and it was recommended:

That the report of the Board of 1908 on Plan and Scope of Work should be followed out; "the instrument to be put in good condition for fundamental work in right ascension and declination, to be thoroughly tested for its fitness for such work, and if found suited to it to be continuously employed in fundamental work on the sun, stars, and such other objects as may be considered desirable;" that these observations should be conducted for a year, the results reduced and compared with one another and the standard catalogues of precision; that azimuth and latitude be determined morning and evening from successive culminations of the same stars; that reflection observations be made in both right ascension and declination; that the flexure be determined at frequent intervals by horizontal and vertical collimators; that the division errors be determined; that during this year the aim should be not to accumulate a great number of observations, but to demonstrate the ability of the instrument to do first-class work in accordance with the plan proposed.

THE CLOCK VAULT.

This was in charge of Prof. M. Updegraff, U. S. Navy, from July 28, 1908, it having been in charge of Prof. W. S. Eichelberger, U. S. Navy the first four weeks of the year. Mr. Hammond, assistant astronomer, has been in immediate charge since October 3, 1908. Close attention to and intelligent consideration of the difficulties which had prevailed to cause fluctuations in the temperature have removed these troubles and secured practically a constant temperature. The performance of the clocks in the vault is excellent. There has been no inconvenience from dampness or humidity in the vault, and no damage to the mechanism of the clocks has ever resulted from this cause, whether inclosed in air-tight cases or not.

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DIVISION OF THE 9-INCH TRANSIT CIRCLE.

This division was in charge of Prof. F. B. Littell, U. S. Navy, from October 1, 1908. For the first three months of the year the instrument was in charge of Prof. W. S. Eichelberger, U. S. Navy.

The Board of 1908 on Plan and Scope of Work recommended for this instrument as follows:

Continuation of the series of observations now being carried on until finished. If the 6-inch is found to be suitable for the fundamental work for which it was designed, the 9-inch should be used for differential work in observing the moon and planets and fainter stars.

The board is of the opinion that it is advisable to leave to the future a final decision as to the instruments to be used for the sun, moon, and planet work, but that unless later developments should make it seem inadvisable, the transit circles should be employed as indicated above.

The work of the determination of the right ascensions and declinations of the sun, moon, planets, and of the stars of Newcomb's Suggested List of Fundamental Stars was accordingly continued up to May 1, 1909.

On the 29th of April, 1909, the council recommended that the sun, moon, and planet work of this instrument should be done in such a way that it may be reduced fundamentally as well as differentially. Since this date the work has been done accordingly.

The report of the Superintendent for June 30, 1908, gives ten months, or until May 1, 1909, to complete the desired observations of the stars in Newcomb's Suggested List of Fundamental Stars. When this date arrived it was found that the instrument had been used clamp west and that it would be good practice to secure certain possible eliminations by continuing these observations for another year clamp east. The work is therefore proceeding.

On June 23, 1909, the council recommended the following plan of work for this instrument for the fiscal year 1910:

Observations of sun, moon, planets, reference stars, and certain clock stars of Newcomb's list, so made as to be reduced fundamentally as well as differentially. The sun, moon, and inferior planets to be observed every day when possible, except Sundays and holidays, when the sun and planets may be omitted, and also the moon when it culminates between 8 a. m. and 5 p. m. The superior planets to be observed at least 15 times when culminating between 2 a. m. and 10 p. m., the observations to be distributed with approximate symmetry with respect to the date of opposition. Mars to be observed 20 times between 3 a. m. and 9 p. m. Necessary observations for investigating instrument to be continued.

During the year observations have been made with screens for personal equation for magnitude, of zenith stars in reversed positions of the observer's body for bisection errors and errors due to direction of motion, and of reflected stars in zenith distance for flexure determination. The flexure has also been determined by the use of the horizontal and vertical collimators. Various bisection errors of the observers have been investigated by means of reversing prism eyepieces. The pivot irregularities have been measured by means of an improved axial microscope, and it has been shown that they are probably much smaller than the previous measures have indicated.

The division errors of 20 lines of the circle were redetermined and compared with the previous values. In general the agreement was fairly good, but in some instances there seemed to be evidence of change.

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In January a determination of the micrometer screw value at low temperature was made.

The instrument was used clamp west until May 1, 1909, and clamp east since that date. The number of observations is as follows:

Standard stars	3,643
Screen stars	393
Zenith stars	339
Reflected stars	134
Sun	171
Moon	138
Mercury	75
Venus	101
Jupiter	15
Saturn	15
Uranus	14
Neptune	16
Total	5,054

The apparent declinations, except corrections for division errors, flexure, and variation of latitude, are completed to August, 1908, and nearly completed to January, 1909. In right ascension the clock corrections have been applied to November, 1906, and they are adopted and ready for application to April, 1908.

THE NEW CLOCK VAULT.

The work of constructing this vault has proceeded to completion. It was in charge of Prof. F. B. Littell, U. S. Navy. It is not expected to use it at present.

DIVISION OF THE EQUATORIALS.

This division was in charge of Prof. Asaph Hall, U. S. Navy, from July 28, 1908, to the end of the fiscal year. For the first four weeks of the year Prof. W. S. Eichelberger, U. S. Navy, was in charge. The work of the two instruments in this division, as recommended by the Board of 1908 on Plan and Scope of Work, is as follows:

26-inch equatorial.

Observations of satellites and measures of diameters of planets.
Observations for stellar parallax.
Observations of positions of minor planets and comets.
Observations of occultations of stars by moon.
Miscellaneous work such as may be decided upon; as, for example, physical observations of the planets, observations of double stars, nebulæ, clusters, and variable stars at their minima.

12-inch equatorial.

Observations of occultations of stars by the moon.
Observations of comets and the brighter asteroids.
Observations of variable stars.
Visitors.

The work done is as follows: Observations of—

VI satellite of Jupiter	6
Satellites of Saturn	118
Satellites of Uranus	31
Satellite of Neptune	27
20 asteroids	92
2 comets	23

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Occultations of stars by moon..... 22
Diameters of Jupiter..... 18
Diameters of Neptune..... 17
Star Bossert 1018 for parallax..... 9
Arc in Pleiades for micrometer screw..... 22
Position of instrument..... 20

On April 29, 1909, the council recommended that the printing of the Equatorial Volume be proceeded with, the copy being then ready for the printer. This volume is No. VI, Naval Observatory, Second Series, and contains the work of the equatorial instruments from 1893 to 1907, inclusive. The printing fund of the Navy Department having been exhausted, it was found to be necessary to let the printing go over until the fiscal year 1910. The work is of high value and should be published as soon as possible.

Three orbits and three ephemerides of asteroids have been computed during the year by Mr. Frederickson.

The observations of the satellites of Uranus have been compared with the data of the Connaissance des Temps. The observations of Neptune's satellite are being worked up, to determine corrections to the elements of the orbit.

As indicated by the summary of observations, considerable attention has been given to the examination of the value of the micrometer screw. A large number of determinations have been made, also, of the position of the instrument and of the different flexures.

The reductions of the observations made on the equatorials, according to the tables issued by the Observatory, are practically up to date.

On June 15 the council recommended the following plan of work for the 26-inch and 12-inch equatorials for the fiscal year 1910:

26-inch equatorial.

Mars: In opposition September 23. Observe satellites and diameters of the planet. Probably some physical measurements like changes in polar cap. August 15–October 15.

Saturn: In opposition October 13. Satellites and diameters of the ball and rings. Of late years it has been the custom to observe the satellites with respect to one another. The following combinations have been made: Mimas-Tethys, Dione-Rhea, Mimas-Rhea, Rhea-Titan, Enceladus-Tethys, Titan-Hyperion, Tethys-Dione, Titan-Japetus, Tethys-Rhea. August 15–November 15.

Uranus: In opposition July 11. Two outer satellites, two inner satellites if possible. Diameter of planet. July 1–August 25, 1909–May 15–July 1, 1910.

Neptune: In opposition January 8. Satellite and diameters of planet. November 1–March 10.

Jupiter: In opposition March 30. Satellite VI, more of faint satellites if possible. Diameters of planet. February 1–May 15.

Halley's comet: To begin a long series as soon as the comet can be observed, observations to extend over, perhaps, six months (January 1–June 30?).

Occultations of stars by the moon.

Eros: (Opposition about May 28, 1910.)

Asteroids: Three to five observations each of such as may be required.

Parallax stars, } for which there may be time.
Double stars, }

With the above, observations are to be made for value of the micrometer screw, position of the instrument, flexures, etc.

12-inch equatorial.

Occultations of stars by the moon.

Brighter asteroids: Three to five observations each of such as may be required.

Some investigations of instrumental constants, value of micrometer screw, etc.

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DIVISION OF THE PRIME VERTICAL.

This instrument has remained in charge of Assistant Astronomer G. A. Hill and has been used steadily in the work of obtaining the aberration and nutation constants and the variation of latitude.

The Board of 1908 on Plan and Scope of Work recommended the work of this instrument as follows:

Observations for variation of latitude.
Observations for aberration and nutation constants.
Observations for declinations of stars.

The work done is as follows:

Observations of 16 stars divided into four equal groups, each group being followed from daylight in the morning through the night until daylight in the evening.
α Lyræ has been observed at every opportunity. Six hundred and twenty-eight observations have been made during the year.

A very thorough examination of the form of the two pivots of the instrument has been made by Mr. Frederick and the observer in charge, using for the purpose an axial microscope. This apparatus consisted of a hand magnifier of 1½-inch focal length, fastened to a tube 39 inches long, and to the latter a filar micrometer was attached. By proper iron support the above was fastened to the south stone pier, on which the instrument rests, the axis of the microscope being placed coincident with the axis of the instrument.

A piece of glass was fastened to the end of the pivot to be measured and on this glass was deposited globules of mercury of about one ten-thousandth of an inch in diameter and then covered with crude balsam. At the opposite pivot an electric lamp was placed, which passed a beam of light axially through the entire instrument. A certain spot of mercury was selected on the plate and then the latter moved so as to bring the spot into practically the center of the field of the micrometer eyepiece.

The microscope used magnifies about 300 diameters and settings on the spot were made at 10° intervals, both in a horizontal and a vertical direction, through a revolution of the instrument.

From a discussion of the measurements made it has been found that the whole range of the quantities secured does not exceed 0.25 of a second of arc and that the range in the level corrections within 15° of the zenith, the part of the pivots resting in the wyes when observations are made, is less than 0.08 of a second of arc.

For the purpose of comparing the variations of latitude obtained at this observatory with those secured at stations in the immediate vicinity, the published results at Philadelphia, Cincinnati, and Gaithersburg, which were secured with the zenith telescope, have been plotted on ruled paper. The latitudes secured with the prime vertical transit instrument have also been plotted thereon for the purpose of studying the curve that will best represent the variation of each.

An inspection of these four curves indicates, in certain parts, that the numerical value of the variation and its phase do not correspond and that the two forms of instruments give different values. The cause for this difference in the variation of latitude between the two forms of instrument has been carefully searched for in the prime vertical observations and it can not be found. The constants used in reducing the prime vertical transit observations have been examined with

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extreme care. Both pivots upon which the instrument rotates have been measured with precision, and they are both practically true cylinders and an appreciable error of level does not obtain in their form.

The average probable error of a single latitude determination is $\pm 0''.108$ for the 16 stars used in obtaining the latitudes.

On June 15 the council recommended the following plan of work for the prime vertical transit:

Observations of four groups of four stars each for variation of latitude and aberration and nutation constants.
Observations for declination of stars.

DIVISION OF THE ALT-AZIMUTH.

This instrument has been in charge of Prof. F. B. Littell, U. S. Navy. As before reported, it was dismounted in July, 1907, and sent to The Warner & Swasey Co. for repairs. It was not returned until April of this year (1909).

The Board of 1908 on Plan and Scope of Work recommended for this instrument as follows:

Observations for absolute or fundamental declinations of the sun and fixed stars.
Observations for atmospheric refraction.

The work done covers the reduction of the 5,400 observations secured from 1903 to 1907, which is nearly complete. The reduction of the 2,500 observations secured before 1903 has been barely started.

The repairs made to the instrument covered the regraduation of the vertical circle on a strip of gold-silver and the regrinding of the pivots. In doing this last the eccentricity of the circle, which had been inconveniently large, was considerably reduced. Examination of the pivots by the spherometer caliper shows them to be very nearly perfect.

New scores were cut and new threads inserted in the microscopes. Besides the two sets of double threads, distant two and a half minutes from each other, used for the regular work, others are provided at distances of two minutes and ten minutes, respectively, for convenience in division error work.

The microscopes do not give as good definition as they should, and it is recommended that new objectives be secured. The power of the microscopes should be higher also.

On June 15 the council recommended the following plan of work for 1910:

Any investigations of instrument which may be necessary for the reduction of past work.

WASHINGTON ZONE CATALOGUE, 1846–1852.

The work of the Washington Zone reductions has been carried on by Prof. W. S. Eichelberger, U. S. Navy.

The reductions of the 7,000 unpublished observations of 1847, 1848, 1851, and 1852 have been completed; the observations have been copied on cards, and the zone corrections have been determined and applied.

The rereduction of all the published transits has been finished.

In order to avoid the introduction of a systematic error due to the motion of the solar system from the date of observation of the zones to that of the Cordoba General Catalogue—the catalogue used for the

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determination of the zone corrections—the systematic differences between the Cordoba General Catalogue and the Cape Catalogue, 1850, were determined and applied to the Washington observations.

The first five hours of right ascension are ready for the formation of the printer's copy. It is expected to have the entire work ready for the printer before the next annual report.

ROUTINE COMPUTATIONS AND PROOF READING.

This work has been carried on in charge of Miss Lamson, assistant. It comprises the miscellaneous work in the reduction of observations made with the 9-inch transit circle, the 26-inch equatorial, and the alt-azimuth instrument. Additional work has also been done on the Astronomische-Gesellschaft Zone Catalogue, the Washington Zone Observations, and other incidental work.

PHOTOGRAPHIC WORK.

This work has remained in charge of Assistant G. H. Peters.

The Board of 1908 on Plan and Scope of Work recommended:

Photoheliograph: Photographs of sun at apparent noon.
Photographic telescope: Positions of faint asteroids, faint comets, and miscellaneous objects.
Work in cooperation with 26-inch equatorial.

The following work has been done: Solar photographs taken on one hundred and seventy-seven days with the photoheliograph. The photographic telescope has not been in continuous use, owing to improvements which are now in course. During the year 26 photographs have been made with it, including asteroid fields and comet Morehouse (1908 C.). Mr. Peters is engaged in the labor of constructing a pair of astronomical photographic objectives of about 10 inches aperture and 110 inches focal length, to take the place of the camera now mounted on this telescope.

On June 15 the council recommended the following plan of work for 1910:

Photograph of sun—photoheliograph.
Photographs of asteroids when required—photo telescope.
Work on new lenses—photo telescope, and completion at earliest possible date. Definitive positions of objects photographed when completed.

ASTRONOMISCHE GESELLSCHAFT ZONE CATALOGUE $-13°\ 50'$ TO $-18°\ 10'$.

This catalogue has been printed and distributed by the Astronomische Gesellschaft of Leipzig, Germany. The catalogue contains 8,824 stars observed by Prof. A. N. Skinner, U. S. Navy (retired) on the 9-inch transit circle, 1894–1905, and forms the fourth volume of the second division of the catalogue of the Astronomische Gesellschaft.

Professor Skinner was engaged until the time of his detachment, June 30, 1909, in preparing material to be used in discussing the proper motions of the stars in this catalogue. All of the observations in other catalogues have been brought up to 1900.0, and the only comparisons still to be made are those with the Washington Zone observations 1846–52. These comparisons can not be made until the work of cataloguing the Washington zones is completed.

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DEPARTMENT OF THE NAUTICAL ALMANAC.

The almanac has continued under the direction of Prof. M. Updegraff, U. S. Navy.

The preparation of the American Ephemeris and Nautical Almanac for the year 1912 is nearly complete, and the volume will be ready as soon as the printing can be done. The volume will contain about 700 pages. The following changes in the Ephemeris for 1912 will be made in addition to those mentioned in the last annual report:

1. Provision will be made for correcting the ten-day ephemerides of stars for the short-period terms of the nutation, and the number of stars will be increased from 383, in previous issues of the Ephemeris, to 825, of which 800 are stars whose apparent places are given for every ten days and the remaining 25 consist of 15 northern and 10 southern circumpolar stars whose apparent places are given for the upper transit at Washington for every day in the year.

2. Improved tables will be given of the positions of the brighter satellites of the planets for the convenience of observers.

3. A series of tables for latitude and azimuth from Polaris will be given for the use of navigators, surveyors, and astronomers.

4. The pamphlet entitled "A List of Stars for Navigators," referred to in the last annual report, has proved to be useful for the purpose for which it was intended. It has been prepared for the year 1909, and added as an appendix to the American Nautical Almanac for that year. It will be enlarged and improved as issued for the year 1912.

The preparation and publication of the Ephemeris for 1912 has been delayed in making the numerous changes needed; but it is hoped that the volume will be distributed before the end of the calendar year.

The publication of Volume IX of the Astronomical Papers of the American Ephemeris has been still further delayed by deficiency in the printing fund of the Navy Department.

The work being done by Prof. Simon Newcomb, U. S. Navy (retired), in cooperation with this department, as mentioned in the last annual report, has been completed and is ready for publication as a part of Volume IX of the Astronomical Papers, and is entitled "Researches on the Motion of the Moon." The eclipses for 1912, as published in the American Ephemeris and Nautical Almanac for that year, will be computed with Professor Newcomb's corrections to the position of the moon.

The investigation of the planet Mars has been discontinued temporarily on account of the pressure of routine work.

The records show that the distribution during the past twenty-seven years of the Astronomical Papers of the American Ephemeris, which have been published, has been irregular and unsystematic, resulting in many incomplete sets of that publication in the libraries of this country and of Europe. It has been discovered that there are in the possession of the superintendent of documents, Government Printing Office, and held for sale, a considerable number of these books. On account of lack of storage room and the small demand at the price charged for them, the Public Printer has had under consideration the destruction of these books as useless. In view

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of these circumstances, information is being collected for the purpose of effecting their distribution to libraries for the completion of sets, and also, in so far as they may be available, to educational institutions and individuals. The superintendent of documents has signified his willingness to transfer the books for that purpose.

There are also available for distribution several hundred copies of a supplement to the American Ephemeris and Nautical Almanac for 1887, bound in cloth, entitled "The Elements of the Four Inner Planets, and the Fundamental Constants of Astronomy," by Simon Newcomb, which is being distributed free as opportunity offers, to libraries and to individuals.

DEPARTMENT OF NAVY COMPASSES.

Lieut. Commander J. S. Doddrige, U. S. Navy, has continued as superintendent of compasses. It is recommended that an assistant be assigned to this department. There is need for a new compass manual. The supply of material for the fleet has been maintained.

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

This department was in charge of Assistant E. A. Boeger until September 23, 1908, when he was relieved by Commander B. W. Hodges, U. S. Navy, who remained until May 20, 1909, when he was detached. The department was then taken in charge by Commander E. E. Hayden, U. S. Navy.

Shipments made and stock on hand.

Fiscal year ending June 30—	Number of shipments.	Value.	Value of stock on hand.
1900	136	$40,123.08	$58,574.27
1901	168	43,864.46	64,453.56
1902	252	61,970.29	57,746.96
1903	309	64,345.25	64,006.53
1904	335	71,719.30	91,404.85
1905	395	99,146.80	94,700.77
1906	400	97,713.12	97,129.32
1907	421	115,954.22	101,815.91
1908	506	150,205.84	124,137.36
1909	489	126,821.17	93,592.25

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department has remained in charge of Commander E. E. Hayden, U. S. Navy.

The usual chronometer trial was carried on between January 4 and June 8. The accompanying tabular statements, Tables I and II, give the data.

The usual work of the department in the rating and issue of chronometers and the sending out of the daily telegraphic noon signals proceeded as heretofore. The mean daily error of the noon signal for the year was 0^s.05, and the maximum was 0^s.32.

A special telegraphic time signal was sent out from this observatory at 12–33–34 a. m., December 22, 1908, by special request, to

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mark the instant when the sun turned north in declination. It was transmitted by telegraph and wireless throughout Alaska, in order to signal the welcome northward motion of the sun and the approaching end of winter.

The New Year's Eve signals were sent out as usual, at midnight, 1, 2, and 3 a. m., to mark the exact instant of the beginning of the new year in each of the great standard time zones of the United States. They were transmitted also as far as Buenos Aires, Australia, Honolulu, Guam, Manila, and Japan.

LIBRARY.

The library has remained in charge of Mr. Wm. D. Horigan, librarian. The space at present available is insufficient and, to remedy this in a measure, it is expected to examine the contents with a view to the withdrawal of matter of no direct value to this institution, and of matter the prospective use of which is highly improbable, and which may be had from the Navy Department and other libraries in this city should necessity arise. The mass of the withdrawals to be considered are publications of departments of the Government.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1908	21,475	4,453	25,928
Accessions	475	96	571
Contents July 1, 1909	21,950	4,549	26,499

Of the accessions, 360 were received as exchanges and 211 were purchased. There were distributed 1,151 copies of the various publications of the observatory.

The routine work is up to date.

BUILDINGS, GROUNDS, AND ROADS.

The buildings require painting and repairs to roofs, gutters, and other incidental repairs, due to wear and tear.

The roads need extensive repairs and the walks some considerable repairs. Some new walks are necessary. The grounds require much work to put them in good condition, this particularly on the lawns.

All of this work will be commenced with the new fiscal year and will be carried on so far as funds will permit.

During the past fiscal year the following work was done: Laid 400 feet water connection; 500 feet sewer pipe from dormitory; 900 feet underground conduit for electric wires; 500 feet concrete walk; graded hill north of Superintendent's quarters; redressed road from main building; filled in gully on Massachusetts avenue with 10,000 cubic yards earth; made 500 feet new road from north entrance Massachusetts avenue; laid 900 feet of gutters and 300 feet of 12-inch sewer pipe to drain new road; graded southeast of barns; filled an unused well.

In the matter of the property lying within the observatory circle not yet acquired by the Government, there are two pieces, one of 1.732 acres belonging to the Normanstone property, and the other of

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6.764 acres belonging to the District of Columbia and occupied by the Industrial Home School. The condemnation proceedings for the acquirement of the piece of 1.732 acres is yet before the court, but I learn that it is expected to finally pass upon the questions involved in October of this year. Upon the decision of the court will depend what action may be necessary to carry out the provision of the joint resolution of Congress, approved August 1, 1894, looking to the purchase of the property of which this piece forms a part. There is held available in the United States Treasury for the purchase of this piece of land $15,089.18. The transfer of the Industrial Home School property from the District of Columbia to the United States awaits the necessary appropriation by Congress, the sum involved being $184,404, for which I recommend that Congress be asked to make appropriation.

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Changes in Personnel.

Name.	Position.	Promoted to—	Date.	Appointed.	Resigned.	Transferred.	Service completed.	Duty.
C. W. Frederick	Assistant at $1,200	Assistant at $1,600	July 1, 1908					Prime vertical.
G. H. Peters	Assistant at $1,400	do	do					Photographer.
Matt Frederickson	Assistant at $1,200	do	do					Equatorial division.
E. D. Tillyer	Assistant at $1,200, Nautical Almanac office.	Assistant at $1,400, Naval Observatory.	do			From Nautical Almanac office.		VI-inch transit circle.
E. A. Lamson	Assistant at $1,200	Assistant at $1,400	do					Computing Division.
R. M. Packard	Assistant at $1,400			Oct. 3, 1908	June 30, 1909			VI-inch transit circle.
Jesse Pawling	Assistant at $1,200					July 1, 1908, miscellaneous computer.		IX-inch transit circle.
John C. Griffin	Stenographer			July 10, 1908	July 20, 1908			Department Chronometers and Time.
S. G. Barton	Assistant at $1,400			July 18, 1908 (temporary).	Sept. 9, 1908			Computing Division.
Bert F. Smith	Stenographer			July 27, 1908				Department Chronometers and Time.
W. M. Smith	Miscellaneous computer.				Sept. 2, 1908			Computing Division.
L. Lindsay	Assistant at $1,000				Sept. 18, 1908			Do.
M. Gundersen	Miscellaneous computer.	Assistant at $1,000	Sept. 23, 1908			July 1, 1909, miscellaneous computer.	June 30, 1909	Do.
H. E. Burton	do			Jan. 19, 1909				Do.
F. F. Harbour	Assistant at $1,000			do				Do.
F. E. Frisby	Miscellaneous computer.			Feb. 16, 1909 (temporary).			May 20, 1909	Do.
J. Robertson	Assistant at $1,600	Assistant at $1,800	July 1, 1908					Almanac.
P. Fisch	Assistant at $1,200					July 1, 1908, assistant at $1,200.		Do.
W. Auhagen	Assistant at $1,600					Nov. 16, 1908		Do.
H. G. Hodgkins	Assistant at $1,400	Assistant at $1,600	Nov. 24, 1908					Do.
A. Snow	Assistant at $1,200	Assistant at $1,400	do					Do.
W. M. Hamilton	Assistant at $1,000	Assistant at $1,200	do					Do.
I. Martin	Piecework computer	Assistant at $1,000	do					Do.
B. J. Sigmund	do			Feb. 6, 1909				Do.
L. Lindsay	do			May 25, 1909				Do.
E. C. Johnson	Copyist, typewriter			July 16, 1908		Oct. 12, 1908, Bureau of Navigation, Navy Department.		Do.
W. A. Meyer	do			Nov. 9, 1908				Do.

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ation No. 16 C 1 of April 30, 1907), United States Naval

r-room. (Orientation changed for polarity test, one week on E., W., S., and N.)

64	68.12	68.57	67.76	70.18	71.51	69.07	65.88	70.99
9	49	52	53	50	51	50	63	70
. 5 12.	Apr. 12 to Apr. 19.	Apr. 19 to Apr. 26.	Apr. 26 to May 3.	May 3 to May 10.	May 10 to May 17.	May 17 to May 24.	May 24 to May 31.	May 31 to June 7.
s.	s.	s.	s.	s.	s.	s.	s.	s.
0.61	+0.53	+0.53	+0.66	+0.41	+0.37	+0.37	+0.53	+0.31
0.81	−0.54	−0.69	−0.57	−0.51	−0.54	−0.46	−0.24	−0.43
0.01	−0.01	−0.34	−0.51	−0.06	+0.07	−0.06	−0.23	−0.07
.57	−1.70	−1.73	−1.93	−1.97	−2.14	−2.24	−1.97	−1.57
0.00	+0.41	+0.39	+0.30	+0.20	+0.29	+0.41	+0.76	+0.40
0.16	−0.10	−0.20	−0.20	−0.30	−0.26	−0.14	+0.24	+0.59
1.77	−1.69	−1.70	−1.91	−2.03	−2.21	−1.96	−2.10	−2.34
0.87	−0.69	−1.10	−1.11	−1.09	−1.17	−0.97	−1.09	−1.24
.40	−1.40	−1.43	−1.70	−1.74	−1.77	−1.73	−1.93	−1.81
0.00	+0.53	+0.39	+0.39	+0.13	+0.19	+0.11	+0.16	0.00
0.63	+0.61	+0.69	+0.59	+0.40	+0.36	+0.49	+0.57	+0.46
1.33	−1.13	−1.33	−1.13	−1.01	−1.07	−1.07	−0.70	−0.20
1.23	−1.31	−1.51	−1.46	−1.41	−1.63	−1.57	−1.16	−0.49
1.66	+1.36	+1.56	+1.63	+1.90	+2.34	+2.19	+2.46	+2.83
1.27	+1.07	+0.84	+0.94	+0.74	+1.06	+1.25	+1.45	+1.35
0.34	+0.33	+0.30	−0.41	−0.11	−0.16	−0.18	+0.36	+1.04
0.23	+0.02	−0.14	−0.30	−0.45	−0.49	−0.42	−0.33	−0.37
2.83	+2.77	+2.61	+2.53	+2.32	+2.22	+2.63	+2.91	+2.65

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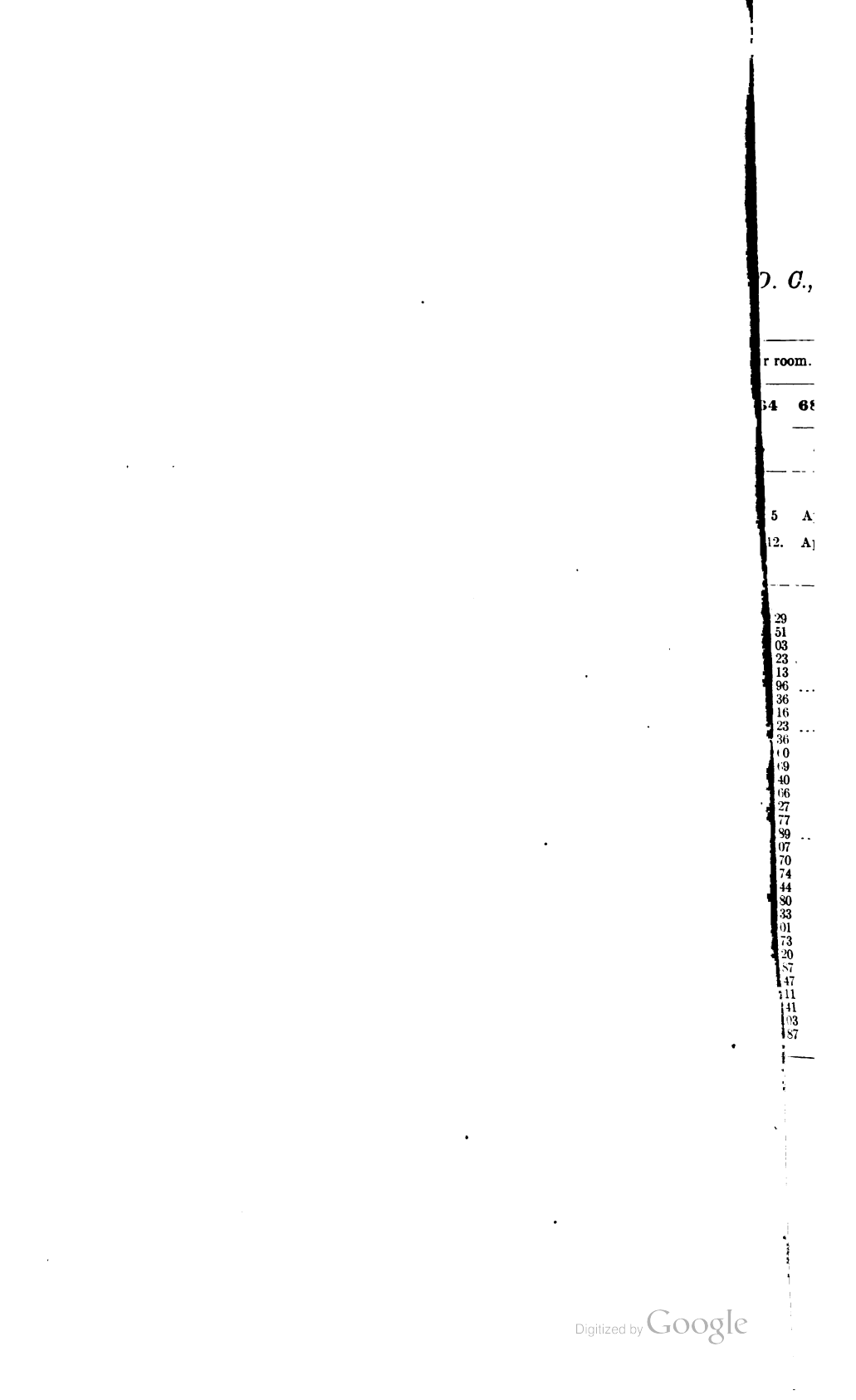
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r room. (Orientation changed for polarity test, one week on E., W., S., and N.)

54	68.12	68.57	67.76	70.18	71.51	69.07	65.88	70.99
	49	52	53	50	51	50	63	70
5 12.	Apr. 12 to Apr. 19.	Apr. 19 to Apr. 26.	Apr. 26 to May 3.	May 3 to May 10.	May 10 to May 17.	May 17 to May 24.	May 24 to May 31.	May 31 to June 7.
	s.	s.	s.	s.	s.	s.	s.	
29	−2.14	−2.36	−2.33	−2.36	−2.37	Issued to Olympia.		
51	−0.30	−0.43	−0.50	−0.53	−0.53	−0.57	−0.49	−0.47
03	+0.99	+0.94	+0.69	+0.93	+0.99	Issued to Rhode Island.		
23	+2.34	+2.14	+2.11	+2.10	+2.17	Issued to Connecticut.		
13	+0.19	+0.31	+0.26	+0.01	+0.13	+0.04	+0.06	+0.07
96	.....	.....		Issued to Mare Island.				
36	−1.57	−1.74	−1.43	−1.90	−2.13	Issued to Nebraska.		
16	+0.23	0.00	0.00	−0.07	−0.06	+0.04	+0.50	+0.51
23	.....	.....		Issued to Mare Island.				
36	+2.56	+2.46	+2.49	+2.79	+2.93	+2.84	+2.96	+2.89
00	+1.43	+1.59	+1.40	+1.39	+1.43	+1.51	+1.80	+1.81
09	−0.74	−0.77	−0.83	−0.90	−0.87	Issued to Rhode Island.		
40	+2.10	+1.99	+1.86	+1.81	+1.97	+2.04	+2.04	+2.10
66	−0.70	−0.66	−1.10	−0.90	−0.79	Issued to Chicago.		
27	+0.96	+0.91	+1.01	+0.89	+0.83	+0.86	+0.89	+0.64
77	+1.59	+1.39	+1.33	+1.27	+1.27	Issued to Olympia.		
89	.....	.....		Issued to Mare Island.				
07	+0.03	−0.04	+0.01	+0.04	+0.16	+0.01	+0.26	+0.60
70	+1.57	+1.66	+1.57	+1.53	+1.63	+1.54	+1.24	+1.33
74	−1.81	−1.89	−1.94	−1.97	−2.03	Issued to Tonopah.		
44	−2.89	−2.84	−2.80	−2.93	−2.91	−2.74	−2.67	−2.80
80	+1.63	+1.50	+1.50	+1.50	+1.67	+1.51	+1.70	+2.06
33	+0.37	+0.40	+0.14	+0.31	+0.53	Issued to Tonopah.		
01	−0.13	−0.19	−0.19	−0.24	−0.30	Issued to Hartford.		
73	+0.34	+0.44	+0.34	+0.16	+0.04	Issued to Hartford.		
20	+0.24	+0.17	−0.29	−0.41	−0.26	Issued to Nebraska.		
87	+2.30	+2.26	+2.19	+1.76	+1.80	Issued to Olympia.		
47	−3.14	−2.89	−3.06	−3.14	−3.01	−3.09	−3.04	−2.93
11	+3.49	+3.03	+3.20	+2.99	+3.03	+3.13	+3.56	+3.40
41	−0.59	−0.67	−0.67	−0.74	−0.63	−0.71	−0.66	−0.86
03	−0.21	−0.14	−0.16	−0.44	−0.57	Issued to Tonopah.		
87	+0.61	+0.73	+0.89	+1.10	+1.04	Issued to Chicago.		

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NAVY DEPARTMENT

UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1910

GOVERNMENT PRINTING OFFICE
WASHINGTON
1910

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SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1910.

In general it may be stated that good progress has been made, although the failure to complete the investigation of the 6-inch transit circle as expected is the cause of some disappointment. When the instrument shall have been fully investigated, as is expected in the course of a few months, if found fit for fundamental work, meridian work will be pursued with a sufficient force to secure large results, while keeping the reductions up to date.

The present period of restricted number of observations is being utilized to bring up back work and to effect such repairs and changes in the instruments as are needed to-day. Under the several headings following in this report will be found more definite statements of reductions made and of the condition of the different instruments.

The continuance of the operations of the council shows good results, which will improve as the members become accustomed to the consideration of matters in general and realize fully the necessity of painstaking individual examination of matters presented.

While no definite understanding has been arrived at, it seems fitting that mention should be made in this report of the attitude of this institution in respect to the scheme of the International Permanent Committee for the Photographic Execution of the Chart of the Heavens, of which M. Baillaud, of the Paris Observatory, is the president. This may be best shown by the following reply to the committee's communications, sent by the Naval Observatory to M. Baillaud:

I have already acknowledged the receipt of your letter of August, 1909, together with inclosures, and now acknowledge the further receipt of a package of papers, all pertaining to the proposed plan for the international observation of the stars for use in reducing photographic observations of the photographic chart of the sky.

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All of these papers have received the careful consideration of the Council of this Observatory, and I present now the conclusions so far as may be definitely made at this moment in regard to the attitude of this Institution.

It is believed to be impracticable at present to use other than the historical fundamental stars as standards. The list which it is expected will be observed here fundamentally on the meridian circle for several years to come comprises nearly all the important historical fundamental stars. Such additional stars of this class as might be agreed upon by the International Committee might be added to this list without unduly extending it, and this matter will receive careful consideration if the Committee shall deem such additional observations here to be desirable. It is assumed that this might cover the stars in the lists of 343 and 1,069 stars.

The proposition to observe the 1,339 stars of Doctor Backlund's list would so extend the observing list as to postpone the completion of the work here by several years. However, after the standard stars above referred to have been satisfactorily observed and determined, consideration might then be given to the proposition to observe the list proposed by Doctor Backlund. It is the desire of this observatory to cordially cooperate in the work of improving the positions of the historical standard stars.

In regard to the observation of the intermediary stars, it is thought that more definite information should be awaited before deciding what can be done here.

I have the pleasure to acknowledge on behalf of this observatory the action of the Committee in constituting its Superintendent a member of the International Committee.

Before making any agreement as to the proposition in its final shape, its terms will be submitted to the Navy Department for its sanction, as required by article 12 of the regulations for the government of this observatory.

It has long been contemplated to assemble as a museum the instruments no longer in use, some of which have been packed away for fifty years. Opportunity offering to carry out this plan, the dome room on the second floor of the main building has been utilized for this purpose. The following instruments are already set up in whole or in part, or are about to be set up, wooden piers being provided as necessary:

One mural circle, made by Troughton & Sims, of London, in 1843.

One refraction circle, made by Ertel & Son, of Munich, in 1846.

One meridian circle, made by Repsold & Co., of Hamburg, in 1850.

One 5-inch equatorial, made by A. Clark & Son, of Cambridgeport, Mass., for observing the transit of Venus in 1874.

One coelostat, made by A. Clark & Son, of Cambridgeport, Mass., for observing the transit of Venus in 1874.

One coelostat, made by Wm. Gaertner, of Chicago, for the solar eclipse of 1905.

One universal instrument, made by Ertel & Son, of Munich, in 1846.

One surveyor's transit, made by Richard Patten & Son, of Baltimore.

One dip circle, made by Kent, of London.

One stellar compass and great circle course projector, invented by Captain Lawless.

One recording inclinometer, invented by Lieut. W. E. Edge, R. N.

One patent compass, invented by J. Peichl.

One compass, made by Elliott Brothers, of London.

One magnetometer, made by Elliott Brothers, of London.

One electric chronograph and clock, invented by Prof. John Locke in 1846

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Department of Astronomical Observations.

THE DIVISION OF THE 6-INCH TRANSIT CIRCLE.

This division was in charge of Prof. M. Updegraff, U. S. Navy, until June 16, 1910, when it was turned over to the charge of Prof. F. B. Littell, U. S. Navy, and remains in his charge.

The recommendation of the board of 1908 on plan and scope of work in regard to this instrument, mentioned in last year's report, has been followed, and it is expected that by the end of this calendar year will have been complied with.

The investigation of the microscope micrometer screws has not been continued, but this will be accomplished at a convenient moment in the near future.

During the year the division errors of the degree lines of circle A have been determined at a high temperature in summer and at a lower temperature in the winter and spring. The results of the two series of measures agree fairly well, the average probable error of the mean of the two determinations of each 5° line being 0″.046 and of the mean of the intermediate degree lines 0″.069. In addition, the division errors of the 5° lines of circle B were determined, and of the 10′ lines for 13 scattered arcs of 1° on circle A, and the 2′ lines for two arcs of 20′ on circle A. The errors of the 2′ lines are periodic in character with a period of 10′ and an amplitude of about 1″.1.

During the year observations for right ascension and declination have been made on selected lists of standard stars, and also observations of stars have been made by reflection for determining the flexure of the telescope, and with screens to determine the personal equations of the observers due to star magnitude. The horizontal flexure has also been determined by the use of the collimators. This flexure is small, probably not more than 0″.1. The vertical or cosine flexure is of about the same magnitude.

In addition to the three lists of stars observed with the 6-inch transit circle during the preceding year, there were three additional lists observed during the year ending June 30, 1910. The observations were made in both clamps, and one of the lists, comprising 13 stars, was observed direct and reflected. In addition to the discussion of the observations already made, it is proposed to make a further series of test observations before beginning regular work. This series will comprise observations on 30 stars, well scattered in zenith distance, using a reversing prism to eliminate the effects of certain personal errors, observing in both clamps, direct and reflected, and with the eye end and objective end interchanged. It is expected that the series can be secured and the results reduced by the early part of 1911.

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The number of observations made during the year is as follows:

Circumpolar stars	395
Equatorial stars	1,454
Inclination stars	57
Direct and reflected stars	106
Screen stars	229
Personal equation stars	241
Total	2,482
Collimation constant	206
Level constant	229
Azimuth constant	339
Nadir constant	224
Runs of microscopes	38
Total	1,036

The reductions of the observations are nearly up to date.

A series of axial collimator measures was made in March, and the results, while differing somewhat from those obtained from the previous measures, indicate that the irregularities of the pivots are very small.

The circle flexures have been measured and the results are $0''.08 \sin(\theta+70°)$ for circle A and $0''.05 \sin(\theta+20°)$ for circle B, where θ is the reading of the circle under the first microscope.

The following new apparatus has been obtained during the year: Three new level tubes of approximately 1,800 feet radius, from A. Pessler, Freiberg; two new eyepieces of 0.35 inch (9 mm.) and 0.55 inch (14 mm.) equivalent focal lengths, giving powers of 126 and 202 diameters, respectively, from Steinheil, Munich; reversing prism eyepieces for the telescope and north collimator, from J. A. Brashear, Pittsburg; and a new observing chair, after the Repsold pattern, with certain improvements, made at the navy-yard, Washington.

For the fiscal year 1911 it is designed to carry on and conclude the investigation of the instrument and if it is declared fit for fundamental work to proceed with that work.

THE CLOCK VAULT.

This vault was in charge of Prof. M. Updegraff, U. S. Navy, until June 16, 1910, when it was turned over to the charge of Prof. F. B. Littell, U. S. Navy. Mr. John C. Hammond, assistant astronomer, has been in immediate charge.

The following clocks have been used as standards during the year: Riefler No. 151 until August 26; Riefler No. 70 from August 26 to March 9; and Riefler No. 151 from March 9 to June 30.

There has been considerable trouble with leakage of air into the glass cases of the clocks, due to deterioration of the cement in the joints. The joints have been recemented and are now air-tight.

When the regulating devices have worked normally, the monthly variations of temperature in the three clock cases have usually been

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less than 0°.1 C. The regulating control failed four times during the year, in no case causing a variation of more than 0°.5 C. in the clock cases. An independent thermostat is so arranged as to give warning when the temperature of the vault changes sufficiently to indicate a failure of the automatic control.

Riefler No. 60 was cleaned in July, 1909. Riefler No. 70 stopped on March 9, 1910, on account of failure of the automatic winding apparatus. It was repaired and has since worked satisfactorily.

THE DIVISION OF THE 9-INCH TRANSIT CIRCLE.

This division has been in charge of Prof. F. B. Littell, U. S. Navy. This instrument has been used throughout the year for the determination of the right ascensions and declinations of the sun, moon, planets, clock stars, pole stars, and a few miscellaneous stars. Observations on stars have also been made with screens for determining magnitude corrections in right ascension, with the reversing prism for determining bisection corrections in zenith distance, and by reflection to determine the sine flexure correction in zenith distance. The horizontal flexure was also determined by means of the collimators, and the pivot irregularities have been measured again with the axial microscope. These irregularities are small. In November, 1909, the wyes were resurfaced by Mr. Fecker of the Warner & Swasey Company, and an improvement in the stability of the rotation axis resulted from this change.

The instrument was used clamp east throughout the year and the number of observations secured is as follows:

Clock stars	3,455
Pole stars	916
Miscellaneous stars	64
Screen stars	332
Prism stars	165
Reflected stars	51
Sun	203
Moon	168
Mercury	89
Venus	75
Mars	20
Jupiter	15
Saturn	15
Uranus	17
Neptune	15
Total	5,600
Collimation constant	794
Level constant from nadir	1,120
Azimuth constant from two marks	1,115
Nadir	1,168
Total	4,197

The state of the reduction of these observations will be found under the head of the Division of Reduction of Observations in Arrears.

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THE NEW CLOCK VAULT.

This vault has been in charge of Prof. F. B. Littell, U. S. Navy. It has not been in use, and has been without artificial heat during the year. The recorded temperatures vary from 69°.4 F. in August to 45° F. in February. The relative humidity has been high in warm weather. At certain seasons of the year, there is condensation on the ceilings of the corridors, and there has been some leakage of moisture through the walls, from the outside. With artificial heat these conditions could probably be successfully controlled by keeping the temperature at a moderately high point.

THE DIVISION OF THE EQUATORIALS.

This division has been in charge of Prof. Asaph Hall, U. S. Navy, there having been incorporated into this division in September, 1909, the photographic work theretofore conducted separately by Assistant George H. Peters.

Observations were made during the year as follows:

Satellites of Mars	61
VI satellite of Jupiter	3
Satellites of Saturn	63
Satellites of Uranus	19
Satellite of Neptune	36
Diameters of planets	24
Occultations of stars by the moon	39
Seven asteroids	13
Five comets	36
Instrumental constants	12
Arcs for micrometer screw	34
Stars measured for Washington Zone Catalogue	87
Stars identified for Washington Zone Catalogue	39

Of the above observations, 5 of comets were secured with the 12-inch, as well as 12 observations of 6 asteroids, 23 occultations, 1 arc for the micrometer screw, and two determinations of the position of the instrument. Also, 50 stars were measured for the Washington Zone Catalogue, and 20 stars were identified.

A series of observations of Halley's comet was obtained, extending over the period November 9, 1909–June 7, 1910. The remaining part of June, 1910, was cloudy, and in July, observations of the comet had to be given up on account of the accumulation of other work. For two weeks, at the time the comet was nearest the earth, it was necessary to give up entirely both the 26-inch and 12-inch equatorials to the use of visitors. The pressure for admittance to the observatory became so great that three 5-inch equatorials were mounted at the Capitol and two assistants were sent there from the observatory to handle them. Also, two small equatorials were placed on the roof outside the 12-inch dome, and two assistants were detailed to them to show visitors.

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It should be noted that the Halley comet committee of the Astronomical and Astrophysical Society of America, through its Secretary, Prof. George C. Comstock, by letter of November 1, 1908, requested this observatory to send a photographic expedition to the Hawaiian Islands to occupy that important station as long as photographs could be secured. This request was not approved by the Navy Department, as such an expedition was deemed to be outside the proper scope of the work of the observatory.

Included in the occultations are those observed during the total eclipse of the moon on November 26, 1909, 8 on the 12-inch equatorial and 10 on the 26-inch.

Various observations made with the equatorials have been published in the Astronomical Journal, including observations of comets, asteroids, satellite VI of Jupiter, and occultations.

The current equatorial reductions are practically completed to date. The discussion is nearly finished of the observations of Neptune's satellite made at the last two oppositions. The measures of Titania and Oberon, outer satellites of Uranus, secured at the last three oppositions, will be discussed during the present calendar year. The observations of the satellites of Mars obtained during the fall of 1909 have been compared with the data of the Connaissance des Temps.

Photographs of the sun were taken at apparent noon on one hundred and fifty-eight days. Solar spots were found on one hundred and forty-seven days. While showing decreased sun-spot activity, compared with the conditions for several years past, the diminution does not correspond to the average condition at this period of the sun-spot cycle.

Volume VI of the Observatory Publications, second series, is now going through the press. In it are included the equatorial observations for the years 1893–1907.

The optical work on the pair of 10-inch astronomical photographic lenses for the photographic telescope has been pushed as rapidly as possible by Mr. George H. Peters, following the curves computed by Mr. E. D. Tillyer. It is expected to have the lenses in use by January 1, 1911. The lens mounts, camera backs, and wrought-iron telescope tubes for the new telescope have been designed by Mr. Peters, and constructed at the Washington Navy-Yard under his supervision.

On account of the work of grinding the new lenses, it has been necessary to omit most of the observations with the photographic telescope, though a number of photographs of Halley's comet were secured.

On Thursday evening of each week visitors have been shown through the 12-inch equatorial, usually by Mr. Peters. Also, a good many special evenings have been given to schools and teachers. A total of 2,250 persons were admitted.

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The Clark micrometer II in use with the 26-inch was sent to the Warner & Swasey Company for some improvements, and also the worm screw which drives the large toothed wheel centered on the polar axis was sent to the same firm (the makers of the mounting) to be reground. As is stated in the forthcoming equatorial volume, there is a four-minute periodic error in the driving mechanism. The curve of this error was smoothed out to some extent by the regrinding, but the error still exists, with the same amplitude, approximately.

At this same time new and finer gears were obtained for the slow motion in declination, in order to increase the accuracy of the determinations of parallel, and better illumination was provided for reading the declination circles.

The following instrumental constants of the 26-inch equatorial determined during the period October 20, 1908–June 23, 1910, are exhibited herewith. They may be compared with those of page F 17, Appendix III, Volume IV of the Publications of the United States Naval Observatory, second series, the values there published forming the basis of the 26-inch equatorial reduction tables contained in the appendix. The notation is the same in the two sets of values.

Constants of the 26-inch equatorial.

Date.	Temp.	η	i_1–c	ξ	$\epsilon \cos \phi$	c	$e \cos \phi$
1908	°	″	″	″	″	″	″
Oct. 20	48.9 F	+113	−62.8	−48.8	.....	.....	.....
Nov. 17	44.8	.....	.....	.....	+102.2	+123.9	+5.2
1909							
Feb. 6	42.0	+107.8	−59.4	−51.5	.....	.....	.....
14	41.9	.....	.....	.....	+ 96.8	+121.3	+3.0
Mar. 20	40.	+111.8	−62.3	−48.4	+ 86.0	+111.6	−1.7
Apr. 2	42.9	.....	.....	.....	+ 93.3	+118.1	+5.2
3	46.8	+108.2	−60.8	−54.5	.....	.....	.....
6	63.	+109.6	−56.6	−56.2	.....	.....	.....
6	63.0	+110.8	−57.6	−59.4	.....	.....	.....
12	61.8	.....	.....	.....	+ 93.8	+116.2	+5.7
May 5	63.	+111.2	−61.2	−53.9	.....	.....	.....
7	63.3	.....	.....	.....	+ 90.6	+115.0	+1.8
10	59.	+107.6	−62.9	−56.1	+ 95.4	+115.3	+3.9
11	57.	+111.2	−60.2	−53.6	+ 91.5	+114.9	+3.3
June 11	70.5	+109.8	−59.6	−54.0	.....	.....	.....
14	68.7	.....	.....	.....	+ 92.5	+113.0	+4.1
17	72.	.....	.....	.....	+ 91.5	+111.7	+5.2
18	74.8	+110.3	−59.4	−57.6	.....	.....	.....
18	64.	.....	.....	.....	+ 91.5	+112.3	−0.4
19	69.	+109.6	−59.7	−58.5	.....	.....	.....
30	80.	+108.2	−59.8	−56.9	+ 87.1	+110.1	+5.7
July 2	78.2	+110.3	−59.3	−56.0	+ 88.1	+111.0	−0.3
Sept. 2	65.0	+112.6	−60.0	−67.0	.....	.....	.....
6	65.0	.....	.....	.....	+ 86.4	+108.8	+5.1
7	67.6	+112.1	−60.4	−66.1	.....	.....	.....
10	67.7	.....	.....	.....	+ 84.3	+110.2	+5.0
28	57.	+108.1	−57.6	−71.4	+ 93.9	+117.3	+1.9
29	59.5	.....	.....	.....	+ 87.1	+112.6	+5.8
30	62.2	+110.3	−60.9	−69.4	.....	.....	.....
Oct. 28	40.0	.....	.....	.....	+ 98.4	+118.6	+7.0
29	41.	+111.9	−60.8	−62.2	.....	.....	.....
Dec. 1	43.0	+113.1	−60.6	−64.1	+ 89.4	+114.8	+6.1
1910							
Jan. 7	26.	+111.5	−59.8	−63.9	+ 91.8	+116.9	+5.9
25	29.5	+111.2	−60.6	−57.2	+ 84.9	+111.3	+6.8
Mar. 21	46.0	+109.8	−58.8	.....	+ 92.1	+114.4	+0.6
23	61.0	+114.9	−60.4	−61.0	.....	.....	.....
25	70.7	+114.4	−62.8	−61.5	+ 92.4	+113.6	−0.1
June 23	83.3	+112.7	−55.9	−69.8	+ 96.3	+117.3	+3.0

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Torsion of the tube.

Date.		Temp.	f
1909		°	°
June	12	.....	+0.010
	14	82. F	0.009
	20	83.	0.016
	20	83.	0.012
	23	75.	0.017
	23	75.	0.014
Sept.	15	72.4	0.009
	15	73.0	0.015
1910			
July	7	75.6	0.015
	7	80.8	0.015
	8	78.6	0.008
	8	85.4	0.016
	12	83.6	0.016
	13	83.8	0.015
	18	75.2	0.014
	18	77.8	0.015
Aug.	3	80.1	0.017
	7	74.2	0.012
	7	74.4	0.015
	8	74.0	0.011
	8	74.4	+0.016

Mean=+0°.014.

Evidently the 26-inch mounting continues to be very steady and is a good piece of mechanical engineering. On August 21, 1909, one of the doors of the pier was left open and was hit by the elevating floor. This may explain the change in the value of ξ between July 2 and September 2.

THE DIVISION OF THE ALT-AZIMUTH.

This division has been in charge of Prof. F. B. Littell, U. S. Navy.

It has not been in use during the year for star observations, but several sets of measures for determining the horizontal flexure by the method of opposed collimators have been made. From a discussion of the results of 15 sets of measures the value $+0''.79$ sin z. d. has been adopted as the correction to observed zenith distances. The probable error of the adopted value is $\pm 0''.063$, indicating considerable accidental error in the separate determinations.

The reduction of the 5,400 observations secured from 1903 to 1907 is practically finished, but the results require further discussion. This is in course. The reduction of the 2,500 observations secured from 1898 to 1903 has been begun, and considerable progress has been made.

In the spring of 1910, after a prolonged spell of very damp weather, it was found that there was a recurrence of the trouble of rust on the steel circle, notwithstanding the fact that it had been copper plated, silver plated, and then painted to protect it from corrosion.

The circle has been returned to the Warner & Swasey Company to be put in good condition and for experiments looking to the securing of better results in this respect. At the same time some

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minor changes and repairs will be made, the principal item being a provision for obtaining field illumination from a mirror on the objective instead of from a small metallic reflector in the center of the cube as at present.

The matter of securing better microscopes with increased power for reading the circle has been under consideration, but definite action has not yet been taken.

It is expected to have this instrument remounted and ready for work by the end of this calendar year. The project of making the ends of the telescope interchangeable was given much consideration, but it has been abandoned for the present.

THE DIVISION OF THE PRIME VERTICAL.

This division has been in charge of Assistant Astronomer G. A. Hill.

This instrument has been used steadily in making observations in the work of obtaining the aberration and the nutation constants and the variation of latitude. The plan of observing 16 stars divided into 4 groups of 4 stars each has been continued.

A new micrometer for the instrument was procured from the Warner & Swasey Company, of Cleveland, Ohio. To shorten the interval during which a star is passing across a group of threads, the spaces between successive threads have been reduced as small as possible and as now arranged they are only half as wide as they were in the old micrometer. This reduces the time needed for noting transits by the same amount and renders less liable any change in the constants during the interval. The same plan of double sets of threads as obtained in the old micrometer has been adopted in the new one and permits of obtaining transits both direct and by reflection over mercury.

An order has been placed with A. Pessler & Son, of Freiberg, Saxony, for a level tube.

There is now being constructed a west azimuth mark for the instrument.

The observations up to January 1, 1907, are reduced and checked. Those of 1908 are reduced to apparent place. Those of 1909 are not yet copied on sheets.

THE DIVISION OF REDUCTION OF OBSERVATIONS IN ARREARS.

This division is in charge of Prof. W. S. Eichelberger, U. S. Navy, and comprises the duties mentioned in last year's report as being then in charge of Professor Eichelberger and of Miss Lamson. Its duty at present consists in the reduction of back work, proof reading, and a part of the routine reduction of current observations.

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The work on the Washington Zone Catalogue, 1846–1852, has been completed with the exception of the identification of a certain few stars upon which both the 26-inch and 12-inch equatorials are engaged. The results of these searches will be entered on the proof sheets. The work will appear in a short time as Volume VII, Publications of the United States Naval Observatory, second series. It was sent to the printer in May, 1910, and 281 pages are now in type. This volume contains the positions of 23,626 stars between 13° 35′ and 45° 25′ south declination, based on 44,500 observations made at the Naval Observatory, 1846–1852.

Volume VI, Publications of the United States Naval Observatory, second series, was sent to the printer in February, 1910, and is in type. It contains the equatorial observations from 1893–1907, both inclusive, and has three appendices:

Appendix I.—Miscellaneous astronomical papers by members of the Naval Observatory staff, including three papers on satellite orbits, one on the solar parallax from observations of Eros, 18 asteroid orbits, and 12 comet orbits.

Appendix II.—Miscellaneous reports on the transit of Mercury, November 10, 1894.

Appendix III.—List of publications issued by the United States Naval Observatory, 1845–1908.

The reduction of the observations made with the 9-inch transit circle, 1903–1910, is well advanced, and it is expected that this work will be ready for the printer in the autumn of 1911. It includes at least 4 observations of each of the stars in Gill's Catalogue of 2,798 Zodiacal Stars, 4 of each of the stars in Hedrick's Zodiacal Catalogue, and 10 of each of the stars in Newcomb's Suggested List of Fundamental Stars. From 30 to 100 or more observations have been secured of each of the clock and azimuth stars. Except for the application of the clock correction after May 1, 1909, the reduction of these observations is completed to May 6, 1910.

The reduction of the sun, moon, and planet observations, about 3,000, for this same period, is in practically the same state.

During the year 27,400 star observations have been copied on cards, including all the observations made up to April, 1907. These observations have been grouped by clamps and observers and the differences determined for pairs of observers, taking the north and south stars separately.

In May the reduction of 2,500 observations made on the alt-azimuth instrument from 1898–1903 was commenced and good progress has been made. These, together with the 5,400 observations, 1903–1907, which have already been reduced, will be ready for the printer in the course of a year.

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Department of the Nautical Almanac.

The Almanac has continued in charge of Prof. M. Updegraff, U. S. Navy.

The expenditure of the piecework fund of $7,000 for pay of computers on piecework for the fiscal year ending June 30, 1910, is as follows:

Name.	Work done.	Compensation.	
Wm. Auhagen	Moon's Long., Lat., and H. P. for 1915	$1,006.25	
	Ephemeris of Mars for 1914	360.00	
			$1,366.25
G. F. Crawley	Ephemerides of the fixed stars for 1910, 1911, 1912, 1913	706.70	
	Ephemeris of Neptune for 1914	70.00	
			776.70
E. B. Davis	Ephemeris of the sun for 1914		375.00
A. Doolittle	Ephemerides of the fixed stars for 1910, 1911, 1912, 1913	447.21	
	Elements of occultations of stars for 1912	48.50	
			495.71
H. B. Evans	Eclipse elements and charts for 1913		234.00
H. B. Hedrick	Ephemeris of Mars for 1913		96.17
H. F. M. Hedrick	Moon's Long., Lat., and H. P. for 1914	143.75	
	Ephemerides of the fixed stars for 1910, 1912	165.60	
	Moon's culminations for 1913	450.00	
			759.35
Louis Lindsey	Ephemerides of the fixed stars for 1910, 1912, 1913		312.50
J. McWilliam	Ephemerides of the fixed stars for 1910, 1912, 1913	358.23	
	Elements of occultations of stars for 1912	165.34	
	Elements of occultations of stars for 1913	239.00	
	Moon's culminations for 1912	48.50	
			811.07
G. B. Merriman	Work not yet completed (satellites for 1914)		
F. E. Ross	Ephemeris of Mercury for 1913	611.00	
	Ephemeris of Venus for 1914	415.00	
	Satellite work and moon corrections	131.00	
			1,157.00
B. J. Sigmund	Ephemerides of the fixed stars for 1910, 1911, 1912, 1913		399.20
T. E. Trott	Ephemerides of the fixed stars for 1910, 1912, 1913		217.05
	Total		7,000.00

The American Ephemeris and Nautical Almanac for the year 1912, enlarged and improved as described in the last two annual reports, was printed and distributed in December, 1909. In this volume the length and breadth of the book are somewhat reduced without reducing the size of the type or the amount of matter on each page, and the quality of the paper used is better. It contains 737 pages as against 603 pages in the volume for the year 1911, the latter including 74½ pages of lunar distance tables which, as stated in the last annual report, are omitted from the volume for 1912. Of the 209 new pages, 40 are due to the placing of 4 instead of 5 ephemerides of ten-day stars on a page, in order to make possible the use of larger type, leaving 169 pages of new matter.

The large number of changes introduced into a single volume of the Ephemeris naturally gave rise to unusual liability to error, and an attempt has been made to meet this contingency by taking unusual care and the adoption of additional safeguards. Thus far nine errors have been discovered and reported.

The preparation of the American Ephemeris and Nautical Almanac for the year 1913 is well advanced, and 525 pages are in type. In

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addition to the contents of the volume for 1912 this volume will contain ephemerides for physical observations of the sun, moon, and planets. The arrangement will be similar to the volume for 1912. It is expected to print the 1913 volume in one edition, and for 1912 and thereafter not to print the appendix "Star list of the American Ephemeris" nor the appendix "Stars for navigators and polaris tables," nor other appendix to the Ephemeris. The "Star list of the American Ephemeris" will be printed for 1911, but not the "Stars for navigators and polaris tables."

The work entitled "Researches on the Motion of the Moon," mentioned in the last annual report as having been done in cooperation with the late Prof. Simon Newcomb, U. S. Navy, is in type and will be published as part 1 of Volume IX of the Astronomical Papers of the American Ephemeris.

The following publications have been received during the year from the Government Printing Office:

300 American Ephemeris and Nautical Almanac, 1910, second edition.
1,000 American Ephemeris and Nautical Almanac, 1912.
720 American Nautical Almanac, 1910, second edition.
507 American Nautical Almanac, 1912.
1,257 Stars for Navigators, 1910.
999 Star List of the American Ephemeris, 1910.

The distribution of the publications of this office during the year is as follows:

Name of publication.	Naval service.	Other departments.	Superintendent of Documents.	Free distribution.	Total.
American Ephemeris and Nautical Almanac	586	659	230	510	1,985
American Nautical Almanac	601	201	26	9	837
Astronomical Papers	75	.....	1	688	764
Stars for Navigators	874	51	200	289	1,414
Star List of American Ephemeris	266	109	50	573	998

These issues comprise volumes of dates from 1890–1912, both inclusive. It will be noted that the Superintendent of Documents, Government Printing Office, received certain volumes for sale. Hereafter books for sale will not be supplied from this observatory.

Department of Nautical Instruments and General Storekeeper.

The Department of Nautical Instruments and that of the General Storekeeper were both in charge of Commander E. E. Hayden, U. S. Navy, during the entire year.

The work of these departments is increasing in about the same ratio as are the ships which are to be supplied with instruments purchased through this observatory.

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Department of Chronometers and Time Service.

This department has remained in charge of Commander E. E. Hayden, U. S. Navy.

The usual chronometer trial was carried on between January 6 and June 6. The accompanying tabular statements, Tables I and II, give the data.

The usual work of the department in the rating and issue of chronometers and the sending out of the daily telegraphic noon signals proceeded as heretofore. The mean daily error of the noon signal for the year was $0^s.05$, and the maximum was $0^s.26$.

Department of Navy Compasses.

Lieut. Commander J. S. Doddridge, U. S. Navy, continued as superintendent of compasses until December 17, 1909, when he was relieved by Lieut. Commander D. W. Blamer, U. S. Navy, who continued in charge through the fiscal year.

The stock of compass material has been maintained at the navy-yards, new ships have been outfitted, and the outfits of old ships kept in repair.

Library.

The library is in charge of Mr. W. D. Horigan, librarian. The publications comprising the library of the Nautical Almanac and occupying space in the rooms allotted to that department were, during the month of October, taken into the rooms belonging to the library of the Naval Observatory and incorporated with that collection. This transfer consists of 3,998 volumes, of which 3,392 were bound, 563 pamphlets, 2,003 numbers or parts of volumes, five sets of celestial charts, and 25 miscellaneous maps and engravings. Of the bound volumes, 642 were publications of the Nautical Almanac, including six sets of the American Ephemeris and six sets of the Astronomical Papers. All of the books included in the transfer have been catalogued and placed upon the shelves.

The growth of the library has been as follows:

	Volumes.	Pamphlets.	Total.
Contents July 1, 1909	21,950	4,549	26,499
Accessions:			
By purchase	250	4	254
Through exchange	230	52	282
From Nautical Almanac	3,998	563	4,561
Contents July 1, 1910	26,428	5,168	31,596

There were distributed 1,230 copies of the various publications of the observatory.

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In March, about 2,300 feet of wooden shelving were constructed in the basement, under the rotunda of the library, to be used for storage of publications of the institution kept for future distribution, and for shelving books needed for the use of the observatory, but for which space was not available in the rotunda and the stack room. The publications of the observatory have been arranged on these shelves, and the work preliminary to the change of location of the other books is in hand.

The withdrawal of matter of no direct value to the institution and of matter the prospective use of which is highly improbable has not yet been undertaken for lack of time. Endeavor will be made to accomplish this in the next fiscal year.

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ion No. 16 C 1 of April 30, 1907), United States Naval

om. (Orientation changed for polarity test, one week on E., W., S., and N.)

66.92	66.94	67.80	65.29	62.86	63.27	67.39	64.13
51	56	56	56	55	64	66	59
Apr. 11 to Apr. 18.	Apr. 18 to Apr. 25.	Apr. 25 to May 2.	May 2 to May 9.	May 9 to May 16.	May 16 to May 23.	May 23 to May 30.	May 30 to June 6.
s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
+0.76	+0.64	+0.61	+0.86	+0.86	+1.17	+1.03	+1.06
−1.36	−1.47	−1.44	−1.41	−1.47	−1.16	−0.69	−0.61
+0.50	+0.54	+0.67	+0.54	+0.71	+0.51	+0.61	+0.47
+2.77	+2.64	+2.37	+2.44	+2.21	+2.37	+2.90	+2.60
+3.07	+3.07	+2.99	+2.97	+2.99	+3.11	+3.33	+3.14
−0.11	−0.13	0.00	−0.13	−0.11	−0.33	−0.14	−0.01
+0.23	+0.33	+0.66	+0.54	+0.33	+0.36	+0.76	+1.16
−0.33	−0.60	−0.66	−0.69	−0.77	−0.77	−0.69	−0.91
−0.89	−1.24	−1.21	−1.31	−1.39	−1.16	−0.80	−0.86
−1.37	−1.44	−1.46	−1.39	−1.31	−1.44	−1.20	−1.23
+3.06	+2.97	+2.90	+2.90	+2.87	+2.77	+2.87	+2.93
−2.97	−3.00	−2.87	−3.00	−2.93	−2.89	−2.96	−3.33
−0.44	−0.63	−0.76	−0.61	−0.43	−0.57	−0.57	−0.76
−1.31	−1.59	−1.57	−1.51	−1.30	−1.09	−0.67	−0.86
−3.80	−3.63	−3.74	−4.19	−4.27	−4.50	−4.64	−5.19

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C., January 6 to June 6, 1910.

oom. (Orientation changed for polarity test, one week on E., W., S., and N.)

66.92	66.94	67.80	65.29	62.86	63.27	67.39	64.13
51	56	56	56	55	64	66	59
Apr. 11 to Apr. 18.	Apr. 18 to Apr. 25.	Apr. 25 to May 2.	May 2 to May 9.	May 9 to May 16.	May 16 to May 23.	May 23 to May 30.	May 30 to June 6.
s.	s.	s.	s.	s.	s.	s.	
.....	.....	.....	.....		Issued to Cavite.		
.....	.....	.....	.....		Issued to Cavite.		
+2.50	+2.77	+2.80	+2.51		Issued to Delaware.		
.....	.....	.....	.....		Issued to Cavite.		
+0.16	+0.01	+0.33	−0.06		Issued to Minnesota.		
+1.09	+0.97	+1.04	+1.10		Issued to Iowa.		
.....	−0.14	+0.43	+0.34	+0.19	.....	.....	.....
+0.73	+0.53	+0.66	+0.61		Issued to Delaware.		
+0.61	+0.40	+0.31	+0.06	+0.16	+0.26	Issued to Abarenda.	
−0.79	−1.31	−1.24	−0.79	−0.84	−0.90	−0.81	−1.04
−1.39	−1.50	−1.64	−1.30	−0.97	−1.11	−1.41	−1.56
+0.37	+0.27	+0.30	+0.43	+0.49	+0.44	−0.51	+0.44
.....	.....	.....	.....		Issued to Cavite.		
−0.57	−0.90	−0.93	−0.79	−0.83	−0.69	−0.19	−0.40
−0.80	−0.73	−0.99	−0.87		Issued to Minnesota.		
+1.74	+1.53	+1.53	+1.63	+1.66	+1.61	+1.33	+1.24
.....	.....	.....	.....		Issued to Cavite.		
−1.37	−1.71	−2.10	−1.70	−1.69	−1.50	−1.34	−1.36
.....	.....	.....	.....		Issued to Cavite.		
.....	.....	.....	.....		Issued to Cavite.		
−1.09	−1.31	−1.20	−1.07		Issued to Old Point.		
.....	.....	.....	.....		Issued to Cavite.		
+0.57	+0.33	+0.41	+0.71	+0.71	+0.63	+0.63	+0.43
+3.47	+3.34	+3.41	+3.47	+3.33	+3.39	+3.23	+3.16
+0.31	+0.26	+0.31	+0.51		Issued to Minnesota.		
−1.19	−1.57	−1.73	−1.29		Issued to Iowa.		
−0.69	−0.94	−0.81	−0.59	−0.56	−0.47	−0.41	−0.44
+0.54	+0.39	+0.33	+0.56		Issued to Vulcan.		
.....	.....	.....	.....		Issued to Cavite.		
+0.51	+0.31	+0.07	+0.30		Issued to Iowa.		
.....	.....	.....	.....		Issued to Cavite.		
+0.16	0.00	+0.14	+0.24	+0.30	+0.29	Issued to Abarenda.	
.....	.....	.....	.....		Issued to Cavite.		
−1.94	−2.19	−2.10	−1.97	−2.16	−2.03	−1.70	−1.83
+0.09	+0.26	−0.37	−0.27	+0.50	+0.09	−0.03	+0.71

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